STATE OF NEW YORK
DEPARTMENT OF CONSERVATION
WATER POWER AND CONTROL COMMISSION

THE GROUND-WATER RESOURCES OF ALBANY COUNTY, NEW YORK

By

THEODORE ARNOW

Prepared by the

U. S. GEOLOGICAL SURVEY IN COOPERATION WITH THE
WATER POWER AND CONTROL COMMISSION

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DEPARTMENT OF CONSERVATION

WATER POWER AND CONTROL COMMISSION

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GROUND-WATER RESOURCES OF ALBANY COUNTY, N. Y.

By THEODORE ARNOW

ABSTRACT

This report has been prepared as part of a State-wide survey of the ground-water resources of New York being made by the U. S. Geological Survey in cooperation with the New York Water Power and Control Commission. Field work was done during 1946 and 1947, when records were obtained for 492 wells, borings, and springs. Thirty-one water samples also were collected for chemical analysis.

Albany County is favorably located at the juncture of the Mohawk and Hudson Rivers in east-central New York (fig. 1) and is a focal point for travel and communication between New York City, New England, and the Middle West. Most of the industry is located in the eastern part of the county, and this, together with the presence of the State government in the city of Albany, has resulted in the concentration of more than 80 percent of the population on the plain lying east of the Helderberg escarpment. The more rugged terrain west of the escarpment is largely devoted to farming. The climate is temperate, with a mean annual temperature of 48° F. and an average annual precipitation of 37 inches.

The Helderberg escarpment also forms a major geologic boundary. To the east the plain is underlain largely by Ordovician shales, which are folded and contorted near the Hudson River. The folding dies out toward the west and the beds are practically flat-lying where they disappear under the escarpment. The escarpment is formed by Silurian and Devonian limestones; westward the bedrock consists of Devonian limestone, grit, and shale. Throughout the county the bedrock is mantled by unconsolidated glacial or alluvial deposits. These vary in thickness and attain a maximum recorded depth of 370 feet in the buried valley of the Mohawk River, which passes beneath the plain west of the city of Albany.

Precipitation on the immediate area is the source of all ground water in Albany County. Glacial deposits constitute the major aquifers, and water is recovered from these beds mainly by drilled or driven wells. Where unconsolidated deposits are thin or otherwise unproductive, water is withdrawn from the bedrock through drilled wells. The yield of bedrock wells is small when compared to that of wells that tap the productive unconsolidated deposits.

The majority of wells in Albany County supply water for domestic or farm purposes and the average pumpage from such wells is less than 500 gallons per day. Most industrial development is in the urban areas and water used for manufacturing processes is generally obtained from municipal water systems, which in 9 out of 17 cases utilize ground water. The largest of these, the Latham Water District, pumps, on the average, more than two million gallons per day from wells. Ground water in Albany County has a wide range in chemical character, depending upon the formation from which it is obtained. In general, however, water from unconsolidated deposits has a lower total mineral content than does water withdrawn from bedrock.

INTRODUCTION

PURPOSE AND SCOPE OF INVESTIGATION

This report covering Albany County is part of a survey being made by the U. S. Geological Survey in cooperation with the New York Water Power and Control Commission to determine the quantity and quality of ground water available in the State of New York, in order to permit a fuller utilization and conservation of the resources of the State. The areas in the State in which ground-water studies have been completed and in which work is now in progress are shown in figure 1. Reports for Columbia, Delaware, Fulton, Greene, Montgomery, Rensselaer, Schenectady, Schoharie, and Washington Counties are being prepared. Progress reports have been published for areas in Broome and Cortland Counties.

METHODS OF INVESTIGATION

Field work for this report was done in 1946 and 1947. Records were obtained for 492 wells, borings, and springs, and 31 water samples were collected for chemical analysis. Part of the time was spent in the study of the glacial deposits and rock formations which are the immediate source of the ground water.

The locations of all wells and springs for which records are given are shown on plate 1. It has not been possible to check in the field the exact location of some of the sites. In many cases only incomplete records for wells were available from well drillers and owners. Although a few well-drilling firms keep excellent records, a considerable number of drillers do not keep any records except for the depth of wells and lengths of casing used. In these cases other details of construction are reported from memory, if at all. In general, little attention is paid to unconsolidated materials overlying the bedrock. The necessity for detailed information about subsurface conditions for the economic development of ground-water resources, as well as for construction purposes, makes it advisable for well drillers to maintain complete and accurate records. By so doing they will render a valuable service to the people of the State as well as to their own profession.

The wells have been numbered in order beginning with number A 1, and the springs have been numbered in a separate series beginning with number A 1Sp. Although the prefix "A" signifies that the particular well or spring is located in Albany County, its use was considered unnecessary in plotting well and spring locations on plate 1, as the plate covers only the Albany County area. As an aid in reporting a well or spring location anywhere in New York State the entire State has been arbitrarily divided into a system of rectangles, each one of which has a width of 15 minutes of longitude and a height of 15 minutes of latitude. The meridian lines forming the vertical sides of the rectangles have been lettered consecutively across the State from west to east, beginning with "A" and ending with "Z". The parallels of latitude forming the horizontal sides of the rectangles have been numbered consecutively across the State from north to south, beginning with "1" and ending with "17". This explains the "coordinate" letters and numbers appearing in the margins of plate 1 opposite the appropriate meridians and parallels of latitude. In the tables of well and spring records each location is detailed by giving first the coordinates of one corner of the rectangle concerned, followed by two other number-and-letter combinations that indicate the distance in miles and direction from the designated corner of the rectangle to the well or spring being located. For example, well A33 (10X, 2.9S, 2.0E) will be found 2.9 miles south and 2.0 miles east of the intersection of lines 10 and X.

ACKNOWLEDGMENTS

This report was prepared under the supervision of M. L. Brashears, Jr., District Geologist for the U. S. Geological Survey in New York and New England. John G. Broughton, New York State Geologist, and officials of the New York State Museum generously supplied information and publications which were of great help in interpreting the geology of the area. Appreciation is also expressed to the members of the New York State Health Department at Albany who provided information and assistance regarding public water supplies. Among the other state agencies contributing much information are the New York Department of

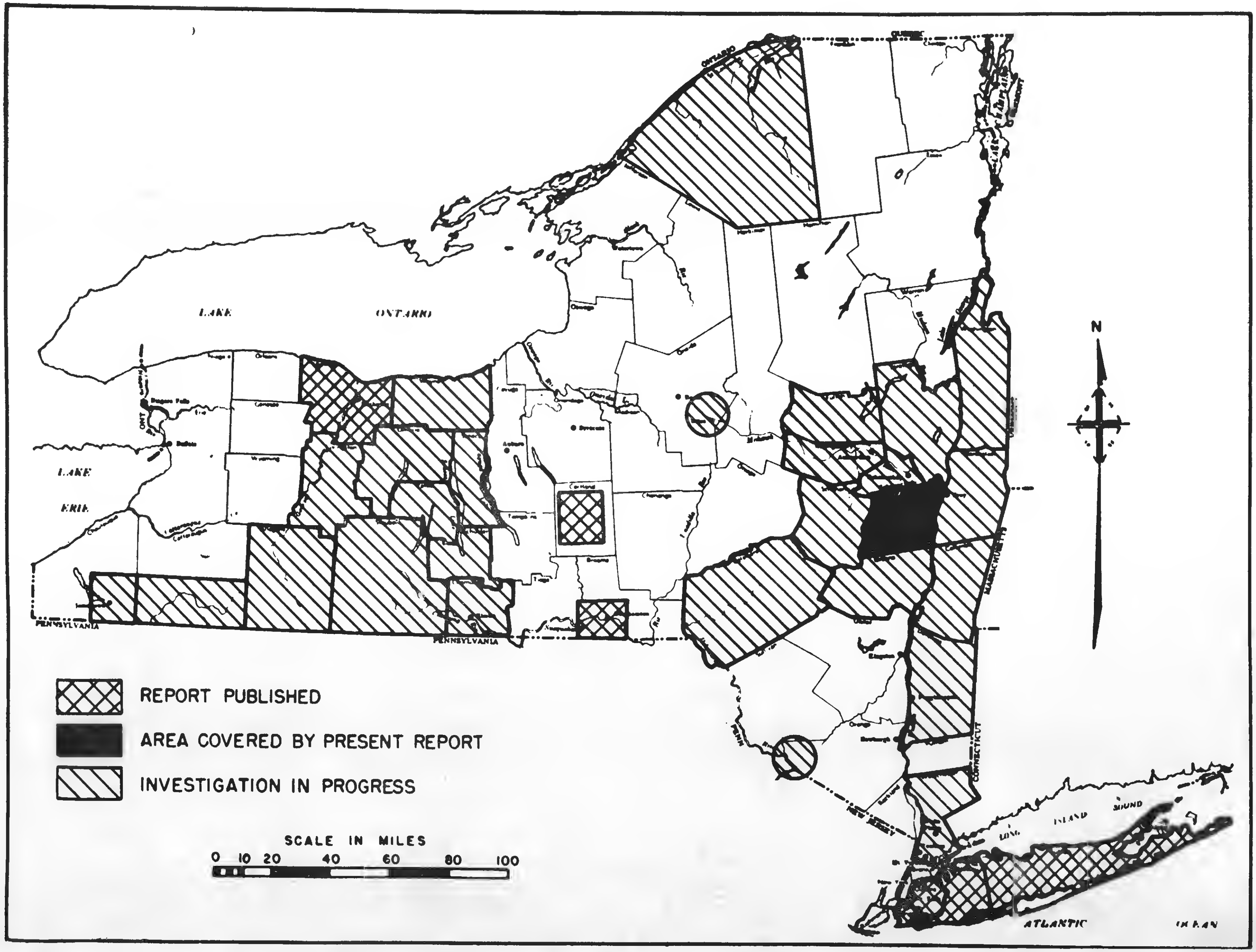

Figure 1.—Index map of New York showing areas of cooperative ground-water studies.

Commerce and the New York Water Power and Control Commission. Thanks are offered also to the many well owners, well drillers, consultants, and municipal officials who provided information without which the report could not have been written. Water samples and well and spring records used in the report were collected by Mr. F. J. Engel, and the samples were analyzed at the laboratories of the New York State Health Department. The writer is indebted to the members of the U. S. Geological Survey, particularly to E. S. Asselstine, for suggestions and assistance provided during the preparation of the report. R. H. Brown of the Geological Survey prepared that part of the report entitled, "Ground water, recovery" dealing with types of wells and general methods of recovering ground water.

GEOGRAPHY

LOCATION AND CULTURE

One of Albany County's chief natural assets is its favorable location. Situated in east-central New York at the juncture of the Mohawk and Hudson Rivers, it has been since the days of Indian occupation a main thoroughfare for travel across the State by both foot and boat, and more recently by train and car. The Hudson River is navigable by ocean-going vessels as far north as the city of Albany, where it connects with the New York State Barge Canal (to Lake Erie and Lake Ontario) and the Champlain Canal (to Lake Champlain). Several major highways converge in the area, and the proposed New York City-Buffalo super-highway is planned to pass through Albany County. In addition, Albany County is served by four major railroads, the New York Central, the Delaware and Hudson, the Boston and Maine, and the Rutland.

Albany County covers an area of 531 square miles and has a population of over 200,000. The average density of population is 416 persons per square mile as compared to 272 for the State as a whole. Eighty percent of the residents, however, live in Delmar, West Albany, Green Island, and the cities of Watervliet, Cohoes, and Albany, all incorporated places of over 2,500 population and therefore considered urban in character.

According to the New York State Department of Commerce, the farming population of the county in 1939 consisted of 2,927 people who were working on 2,177 farms which covered two-thirds of the area of the county. The value of farm property was $13,508,000 and the total value of all farm products in 1939 was slightly over $4,873,000. The manufacturing industries, on the other hand, employed an average of 12,900 people who earned $14,772,000 while turning out $95,093,000 worth of products in 306 plants. The chief industries are printing and publishing, and the manufacture of textiles, machinery and metal products, and stone products. Of the latter the most interesting is the Albany molding sand, which consists almost wholly of quartz grains bonded by clay and is of such excellent quality that it has been used throughout the nation in brass, aluminum, and iron foundries. The value of the molding sand produced in 1946 was $135,000, whereas the value of other stone and clay products amounted to nearly $500,000.

TOPOGRAPHY AND DRAINAGE

The topography of Albany County has been described by Ruedemann[1] as consisting of the remnants of two major peneplains bounded on the east and northeast by the valleys of the Hudson and Mohawk Rivers. The older peneplain covers most of the western part of the county and its eastern limit is marked by the Helderberg escarpment, which rises abruptly just west of Ravena, South Bethlehem, New Salem, and Altamont (pl. 1). The altitude of the top of the escarpment ranges from about 1,500 feet above sea level in the northwestern part of the county to about 800 feet in the southern part of the county. Toward the southwestern part of the county the topography becomes more rugged and the elevation averages from 1,500 to 1,900 feet above sea level. The highest point in Albany County, southwest of Rensselaerville, is 2,110 feet. The topography directly reflects the underlying geology in that the terraces and slopes are developed on the less resistant shaly beds, whereas the cliffs are formed by the tougher, massive limestone formations (fig. 2). A thin covering of soil pierced by numerous outcrops is found throughout most of the Helderberg region, but some of the hill slopes and several of the stream valleys are mantled by thick deposits of till or glacial outwash. Except

[1] Ruedemann, Rudolf, Geology of the Capital district: New York State Mus. Bull. 285, p. 19, 1930.

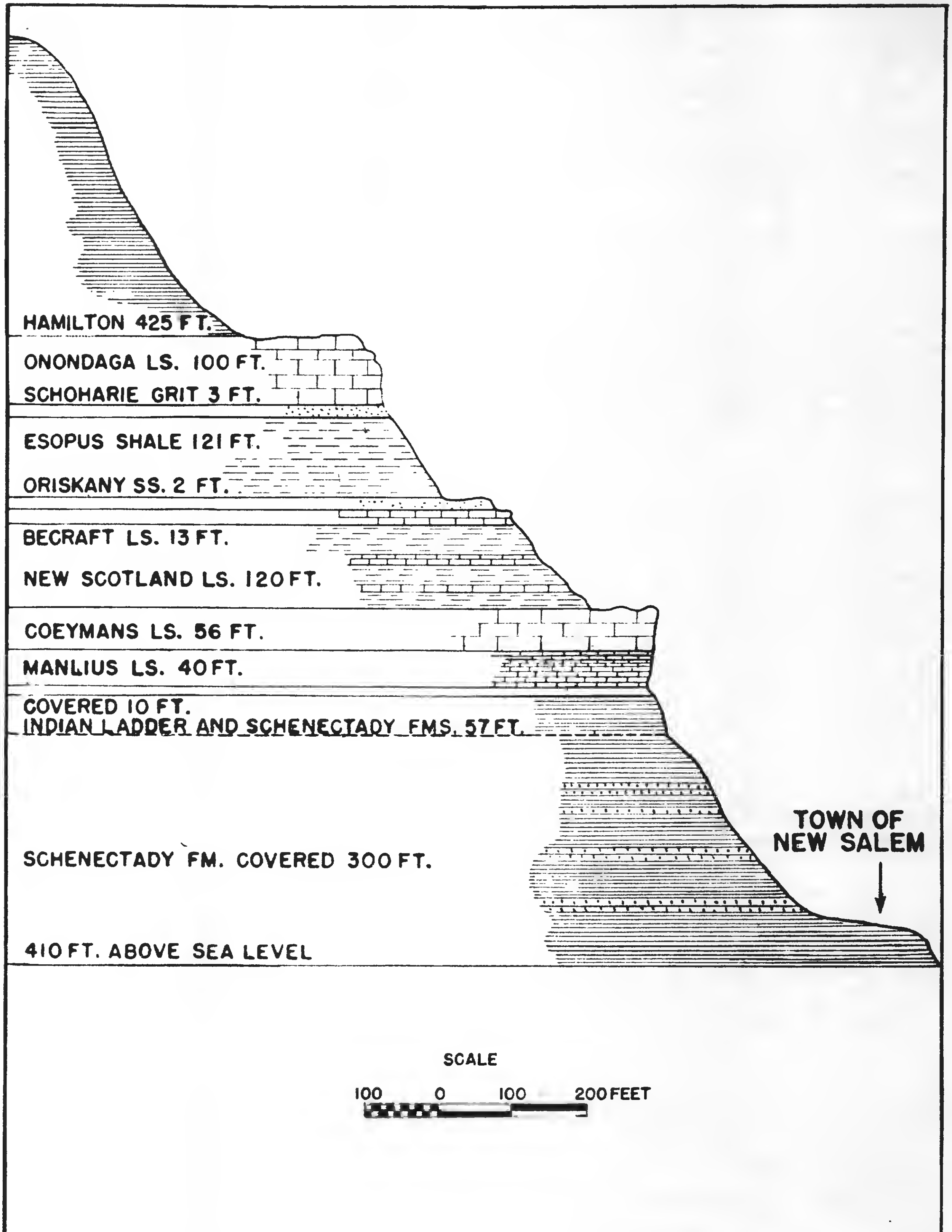

Figure 2.—Countryman Hill near New Salem, New York (modified after Prosser and Rowe, 1899).

for Switz Kill and Fox Creek, which form part of the Mohawk drainage, all the larger streams flow in a southeasterly direction toward the Hudson River. The only large natural lakes in Albany County are in the Helderberg area. There are five small lakes, averaging about an eighth of a square mile in area, near Rensselaerville, and farther north are two lakes about a quarter of a square mile in area. One of the latter, Thompsons Lake, lies in a sinkhole in the Onondaga limestone[2] and is an outstanding example of the karst topography that has been developed over some of the limestone terrane in this region. The largest bodies of water in the county are the Alcove Reservoir and Basic Creek Reservoir, near the Greene County boundary. Together they cover over 2½ square miles and constitute part of the water supply of the city of Albany.

The younger peneplain stretches from the Helderberg escarpment east to the Hudson River. At its southern extremity, near Ravena, the plain is narrow and attains a maximum altitude of about 200 feet above sea level. Extending northward the plain broadens, the altitude increases, and in the northeastern and northwestern parts of the county is as much as 400 feet above sea level. The underlying bedrock consists of Ordovician sandstones and shales, which are flat lying in the west but greatly disturbed toward the east. As the whole area, however, has been thickly covered by glacial deposits, most of which were laid down in standing lake waters, the region presents a generally flat, uniform appearance. This flatland has been dissected by several southeast-flowing tributaries of the Hudson River. The most important of these are Normans Kill, Onesquethaw Creek, Coeymans Creek, and Vlauman Kill. The only large body of water in this area is a reservoir which covers almost half a square mile and is used as a source of supply by the city of Watervliet.

East of the younger peneplain, bounded by steep clay banks rising over 100 feet, lies the valley of the Hudson River. The present stream flows over a bed of glacial fill which has buried an old rock gorge formed during pre-Pleistocene time.[3]

The tributaries of the Hudson occupy postglacial channels and have less erosive power. Thus they have not been able to erode their beds to grade level and many of them now reach the Hudson over a series of waterfalls. These falls serve as an excellent source of water power and have influenced the location of some settlements, particularly Cohoes (on the Mohawk River) and Normansville and Kenwood (on the Normans Kill).

CLIMATE

Meterological records have been maintained at the city of Albany since 1795 and they indicate that the mean annual temperature is 48° F. January is the coldest month, with a mean temperature of 24°, and July the warmest, with a mean of 72°. The highest and lowest temperatures recorded were 104° F. on July 4, 1911, and -24° F. on January 5, 1904. The average date of the last killing frost is April 24, and that of the first is October 16.

The mean annual precipitation in the area is 37 inches. It is fairly evenly distributed throughout the year, with the heaviest precipitation occurring during June, July, and August. These months constitute over half of the growing season, which averages 175 days. The greatest annual precipitation recorded is 56.76 inches, in 1871, and the least is 24.58 inches, in 1941. The mean annual snowfall for the area, included in the foregoing annual precipitation figures, is 50 inches, with almost all of it falling during the months of November to April, inclusive. The heaviest snowfall ever recorded, 110.0 inches, occurred during the winter of 1887-88, and the lightest, 13.8 inches, during the winter of 1912-13.

These precipitation records are compiled from observations taken in the City of Albany and are fairly representative of conditions in the eastern part of Albany County, from the Hudson River to the Helderberg escarpment, where the elevation exceeds 400 feet in only a few places. In the western part of the county where altitudes are higher, reaching a maximum of 2,110 feet, and where the topography is rolling and hilly, the temperatures are lower and the precipitation is somewhat greater.

[2] Goldring, Winifred, Guide to the geology of John Boyd Thacher Park (Indian Ladder region) and vicinity: New York State Mus. Handbook 14, p. 31, 1933.

[3] Cook, J. H., Glacial geology of the Capital district: New York State Mus. Bull. 285, p. 188, 1930.
Berkey, C. P., Geology of the New York City aqueduct: New York State Mus. Bull. 146, p. 95, 1911.

GEOLOGY AND WATER-BEARING PROPERTIES OF THE FORMATIONS

GENERAL GEOLOGY

The geology of all except a small portion of the southwest part of Albany County has been thoroughly described in three publications of the New York State Museum.[4] A generalized stratigraphic column for Albany County is shown in table 1 and the bedrock geology of the county is shown on plate 2.

GEOLOGIC HISTORY

Except for the period represented by a small inlier of the Lower Cambrian Nassau formation at Barren Island, recorded geologic history in Albany County begins during Lower Ordovician time. At that time the area was covered by part of the huge Appalachian sea which stretched from Newfoundland to Alabama and was over 400 miles wide.[5] Early writers stated that the large Appalachian geosyncline was divided into separate north-south troughs by long barrier ridges, and that in each of these troughs an independent sequence of rock materials was deposited.[6] More recently, however, it has been suggested that the entire basin was one continuous unit with deposits of different character, varying according to distance from the old shore line and the source of the material, being laid down simultaneously in different parts of the sea. Ruedemann[7] has summed up the entire situation by saying "It would seem that the varying conditions in the geosyncline allow the conclusion that both working hypotheses may be applied at certain times . . . ."

During Middle Ordovician time Albany County was covered by a deep sea in which were deposited the Normanskill and Canajoharie shales and the Snake Hill and Schenectady formations. The Canajoharie shale, which crops out in only one small area in Albany County, is very closely related to the Snake Hill formation and for the purpose of this report is included with the Snake Hill. The black graptolite-bearing Normanskill and Canajoharie shales represent a total thickness of more than 5,000 feet, and the base of the entire trough must have been sinking rapidly to accommodate the entire sequence. The basin continued to sink, but, owing to very rapid deposition of sediment and the presence of shifting currents, the character of the materials deposited changed and a great mass of alternating sandstones and shales, the Schenectady formation, was laid down. The youngest Ordovician sediments deposited were those of the Upper Ordovician Indian Ladder formation that are restricted to a very narrow trough located in the vicinity of the Indian Ladder at the Helderberg escarpment, west of Albany.

Then followed a long period of emergence and erosion, during which time the Taconic orogenic disturbance took place. The area was again invaded by the sea in late Silurian time. The thin Brayman shale is thought to have been a residual soil, formed during the long erosional period and subsequently reworked and redeposited by the advancing sea.[8] The overlying Silurian deposits consist of three formations, the Cobleskill, the Rondout, and the Manlius limestones.

The boundary between the Silurian and Devonian strata is not strongly marked in the Albany area but the Coeymans limestone, directly overlying the Manlius, is considered to be the first of the Devonian deposits. Overlying the Coeymans limestone are five Lower Devonian fossiliferous limestones, the Kalkberg, New Scotland, Alsen, Becraft, and Port Ewen limestones. Following a fluctuation of the sea, deposition was once again resumed and the Oriskany, Esopus, and Schoharie formations, representing a series of sandy beds, were laid down. The over-

[4] Ruedemann, Rudolf, Geology of the Capital district: op. cit.
Goldring, Winifred, Geology of the Berne quadrangle: New York State Mus. Bull. 303, 1935.
Goldring, Winifred, Geology of the Coxsackie quadrangle: New York State Mus. Bull. 332, 1943.

[5] Ruedemann, Rudolf, Notes on Ordovician plankton and radiolarian of New York: New York State Mus. Bull. 327, p. 56, 1942.

[6] Ulrich, E. O., and Schuchert, Charles, Paleozoic seas and barriers in eastern North America: New York State Mus. Bull. 52, p. 638, 1902.
Ruedemann, Rudolf, Geology of the Capital district: op. cit., p. 132.

[7] Ruedeman, Rudolf, Geology of the Catskill and Kaaterskill quadrangles, pt. 1: New York State Mus. Bull. 331, p. 174, 1942.

[8] Ruedemann, Rudolf, Geology of the Capital district: op. cit., p. 172.

Table 1.—Geologic formations in Albany County and their water-bearing properties.

Age: System	Age: Series	Group	Geologic horizon	Maximum thickness (feet)	Character of material	Water-bearing properties
Quaternary	Recent		Alluvium	50+	Sorted deposits ranging in size from clay to gravel; associated with the larger streams.	A productive aquifer if properly developed. May be subject to stream recharge; if so, water will have chemical characteristics similar to those of surface water.
	Pleistocene		Glacial drift	370+	Till-heterogeneous mixture of unstratified material ranging in size from clay to boulders. Variable in nature and sometimes grading into sorted material.	Extensively tapped by dug wells which obtain sufficient water for household use.
					Outwash-sorted deposits ranging in size from clay to boulders and in many places stratified and cross-bedded.	Fine deposits are practically impervious. Coarse deposits are best aquifer in county. Yields range up to 700 gallons per minute and average 300 gallons per minute in developed wells. Quality of water from glacial drift varies greatly and is dependent upon local conditions.
Devonian	Upper Devonian		Onteora formation	1,150±	Nonmarine fossiliferous red sandstones and shales with conglomerates at the base.	Unimportant as an aquifer. No well records obtained.
	Middle Devonian	Hamilton group	Kiskatom formation	1,000+	Nonmarine, fossiliferous, alternating red, greenish or gray sandstones with interbedded red and green shales. The sandstones are generally heavily bedded.	Yields range under 20 gallons per minute and average 8 gallons per minute. Quality of water is excellent.
		Hamilton group	Ashokan formation	350−	Nonmarine, nonfossiliferous, laminated, arkosic, tough sandstones, which contain interbedded olive shales weathering red or brown.	
		Hamilton group	Mount Marion formation	1,400+	Marine, fossiliferous, primarily thin-bedded sandstones with intercalated beds of dark, often bluish to greenish shales. The sandstones split along the bedding planes into flagstone slabs 1 to 3 inches thick.	
		Hamilton group	Bakoven shale	200−	Black, bituminous, pyritiferous, very fissile shale, characterized by concretions of carbonate of lime in layers or scattered through certain portions.	
	Lower or Middle Devonian		Onondaga limestone	100−	Moderately pure, massive, light blue-gray limestone containing parallel chert lenses. Subject to solutional action, which develops caves and karst topography.	Yields range from 1 to 20 gallons per minute, with a mean yield of about 3 gallons per minute. Water generally hard.
			Schoharie grit	20−	Dark, bluish-gray, impure siliceous limestone, which weathers to a dark buff porous sandstone; shaly in parts. Grades into the Onondaga limestone and is sometimes considered a phase of the Onondaga.	Unimportant as an aquifer.
			Esopus shale	120−	Dark-gray to black grit or sandy shale of a very uniform character, which weathers to a dark-brown color and readily crumbles to gravel.	A productive aquifer; yields average about 20 gallons per minute. Water is very soft.
	Lower Devonian		Oriskany sandstone	4	Dark, bluish-gray, hard, quartzitic sandstone with a strong admixture of calcareous matter. The lime is often dissolved out, leaving a porous brown sandstone.	Unimportant as an aquifer owing to thinness of formation. No well records obtained.
			Port Ewen and Alsen limestones	30±	Transition beds.	Unimportant as aquifers. No well records obtained.
			Becraft limestone	27−	Light-colored, massive, pure, coarse-grained shell rock, which darkens upon weathering.	Unimportant as an aquifer. No well records obtained.
			New Scotland limestone	100±	Dark, blue-gray, thin-bedded, very impure shaly limestone and calcareous shale. Varies from gray to gray-brown when weathered.	Unimportant as an aquifer. Few wells with average yields of 4 gallons per minute. Quality of water good.
			Kalkberg limestone	25−	Transition beds between the Coeymans and New Scotland formations.	Unimportant as an aquifer. Few wells, with average yield of 4 gallons per minute. Quality of water good.
			Coeymans limestone	60−	Bluish-gray, coarse, semi-crystalline limestone composed largely of shells. Hard and resistant and a characteristic cliff-former.	Unimportant as an aquifer. Few wells, with average yield of 3 gallons per minute. Water generally hard.

Table 1.—Geologic formations in Albany County and their water-bearing properties. (Concluded)

Age: System	Age: Series	Geologic horizon	Maximum thickness (feet)	Character of material	Water-bearing properties
Silurian		Manlius limestone	45+	A thin-bedded, dark-blue, pure limestone which contains alternating lighter and darker beds. Very hard and resistant and a characteristic cliff-former. Subject to cave formation.	Unimportant as an aquifer. Few wells, with average yield of 3 gallons per minute. Water generally hard.
		Rondout limestone	14	A bluish-gray, banded, lime mudrock, which weathers to a characteristic brown color. Contains some shaly beds which weather to clay. Subject to cave formation.	No well records obtained. The Rondout underlies the lowermost Helderberg cliff, however, and is the formation through which many springs issue.
		Cobleskill limestone	5	Heavily bedded, semi-crystalline, fossiliferous limestone.	Unimportant as an aquifer. No well records obtained.
		Brayman shale	9	Greenish sandy shale containing much iron pyrite. Crops out only in the Helderberg cliff region.	Unimportant as an aquifer. No well records obtained. Impervious nature of shale prevents further downward percolation, however, and is the cause for the line of springs issuing from the foot of the lowest Helderberg cliff.
Ordovician	Upper Ordovician	Indian Ladder formation	400+	Dark-gray to black argillaceous shales, which alternate with thin, yellow, rusty-looking calcareous sandstone beds. Occasional heavy sandstone bed present.	Unimportant as an aquifer. No well records obtained.
		Schenectady formation	2,000+	Black and gray argillaceous shales interbedded with grits and sandstones of variable texture. Uniformly alternating series showing ripple marks and other signs of shallow-water deposition.	Very poor aquifer; yields average less than 3 gallons per minute; completely dry wells common. Quality of water very poor and a high sulfate content often present.
	Middle Ordovician	Snake Hill formation (including the Canajoharie shale)	3,000+	Lithologically similar to the Normanskill, but without the strong development of chert and grit beds. Also, contains occasional layers of limestone.	Yields range up to 100 but average about 15 gallons per minute. Completely dry wells not uncommon. Quality of water generally poor and a high sulfate content often present.
		Normanskill shale	2,000±	Primarily dark-gray to black argillaceous shales containing heavy beds of chert and grit. Red and green shales are present locally.	Poor aquifer; yields average 4 gallons per minute. Water highly variable in quality but often contains hydrogen sulfide.

lying Onondaga limestone was followed by the Bakoven shale,[9] which in turn gradually gave way to the alternating shales and sands of the Mount Marion formation of Middle Devonian age. Later in Middle Devonian time, as the sea began to shrink, great quantities of continental deposits were laid down. These formed the Ashokan and Kiskatom formations, which, except for a limited deposit of the Onteora formation in the extreme southwestern corner, represent the youngest consolidated deposits in Albany County.

The close of the Paleozoic era was marked by the Appalachian revolution, a time of intense mountain building. As a result of the crustal deformation during the Taconic and Appalachian revolutions, the rocks in Albany County have been faulted and folded in varying degrees. Those in the eastern part of the county are everywhere intensely folded and contorted and, though the general strike is about N. 20° E., they have a wide range of dips. The folding gradually dies out toward the west and disappears near the thrust plane that marks the boundary between the Snake Hill and Schenectady formations (fig. 3). The Schenectady formation west of this zone is undisturbed and has a southwest dip amounting to only 1 to 2 degrees. Except for a few small faults and some occasional gentle open folding, the rocks in the Helderberg region are also undisturbed.

Throughout the Mesozoic and Cenozoic eras Albany County was subjected to a long period of erosion which lasted until the invasion of the Pleistocene ice sheet. One of the larger tongues of this great ice sheet moved down the Champlain-Hudson trough and completely overrode the Helderberg plateau,[10] depositing a great mass of debris which now cloaks most of the surface of Albany County. These deposits brought about major changes in the local drainage pattern. The present course of the Mohawk River from Schenectady to its juncture with the Hudson at Cohoes is of postglacial origin and was established after the ice had melted but had left the preglacial channel completely filled with debris. The old channel extended from the present river bend at Schenectady to a point of confluence with the Hudson about 10 miles south of Albany. The position of this old valley has been defined by Simpson[11] and is shown on figure 4. Another preglacial stream, the Colonie Channel (fig. 4), drained the Saratoga-Round Lake depression and flowed south to join the old Mohawk Channel southwest of the city of Albany. After the Pleistocene ice sheet stagnated and melted away, the present drainage pattern was established and the modern streams assumed the work of erosion and alluvial deposition that is continuing today.

ROCK FORMATIONS

Normanskill shale.—The outcrops of this rock in Albany County are the classic hunting grounds for the largest and best-known graptolite fauna of America. Although termed a shale, the Normanskill ranges greatly in lithologic composition. It consists chiefly of dark-gray to black argillaceous shales but also contains red and green shales and heavy beds of chert and grit. The chert occurs in beds ranging from 2 to 10 feet in thickness and weathers to a characteristic white or light-gray color. The grit is a gray, coarse sandy rock, which along freshly fractured surfaces is very dark in color.[12] The Normanskill strata have been subjected to much folding and contortion and, although its exact thickness is not known, Reudemann[13] has stated that the formation probably has a maximum thickness of as much as 2,000 feet. The Normanskill is an impervious rock and yields only small amounts of water from joint and bedding planes, but because it underlies a large area (pl. 2), which is covered by overburden having poor water-bearing characteristics, it has therefore been tapped by many wells in Albany County.

Snake Hill formation.—Beds of the Snake Hill formation consist primarily of dark-colored, argillaceous shales which, except for the enclosed faunas, are very similar to those of the Normanskill shale. The layers of the grits and white-weathering cherts so evident in the Normanskill, however, are not strongly developed in the Snake Hill formation. Incalations of sandy limestones and also gray crystalline limestone which sometimes reach half a foot in thickness are frequently observed. Owing to the extreme pliability of the shales, the Snake Hill formation has been intricately folded and crumpled. The exact thickness of the formation

[9] Ruedemann, Rudolf, Geology of the Capital district: op. cit., p. 175.
[10] Cook, J. H., The glacial geology of the Berne quadrangle: New York State Mus. Bull. 303, p. 222, 1935.
[11] Simpson, E. S., Buried preglacial channels in the Albany-Schenectady area, N. Y., unpublished manuscript, U. S. Geol. Survey.
[12] Dale, T. N., The slate belt of eastern New York and western Vermont: U. S. Geol. Survey 19th Ann. Rept., pt. 3, p. 188, 1898.
[13] Ruedemann, Rudolf, Geology of the Capital district: op. cit., p. 97.

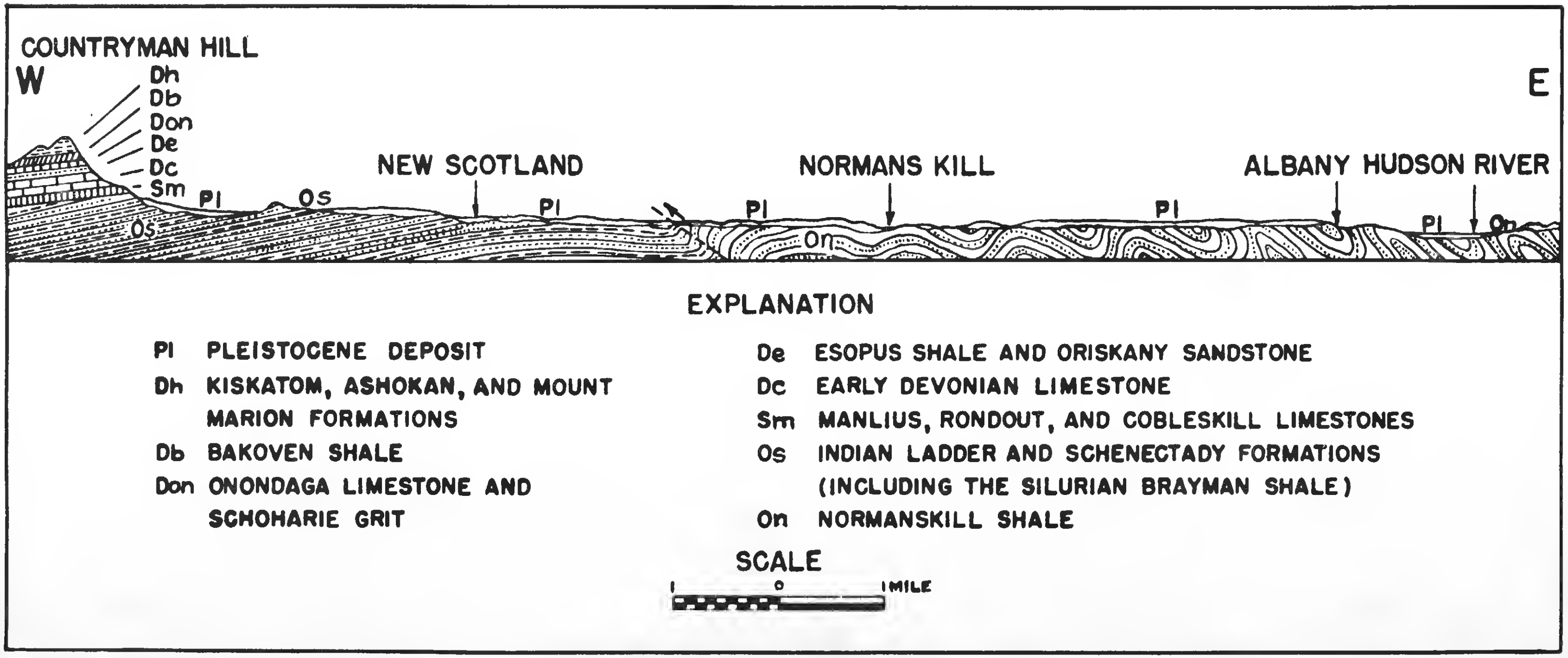

Figure 3.—Generalized cross section from Countryman Hill to the Hudson River showing relationship of folded and flat-lying strata (adopted from Ruedemann, 1930).

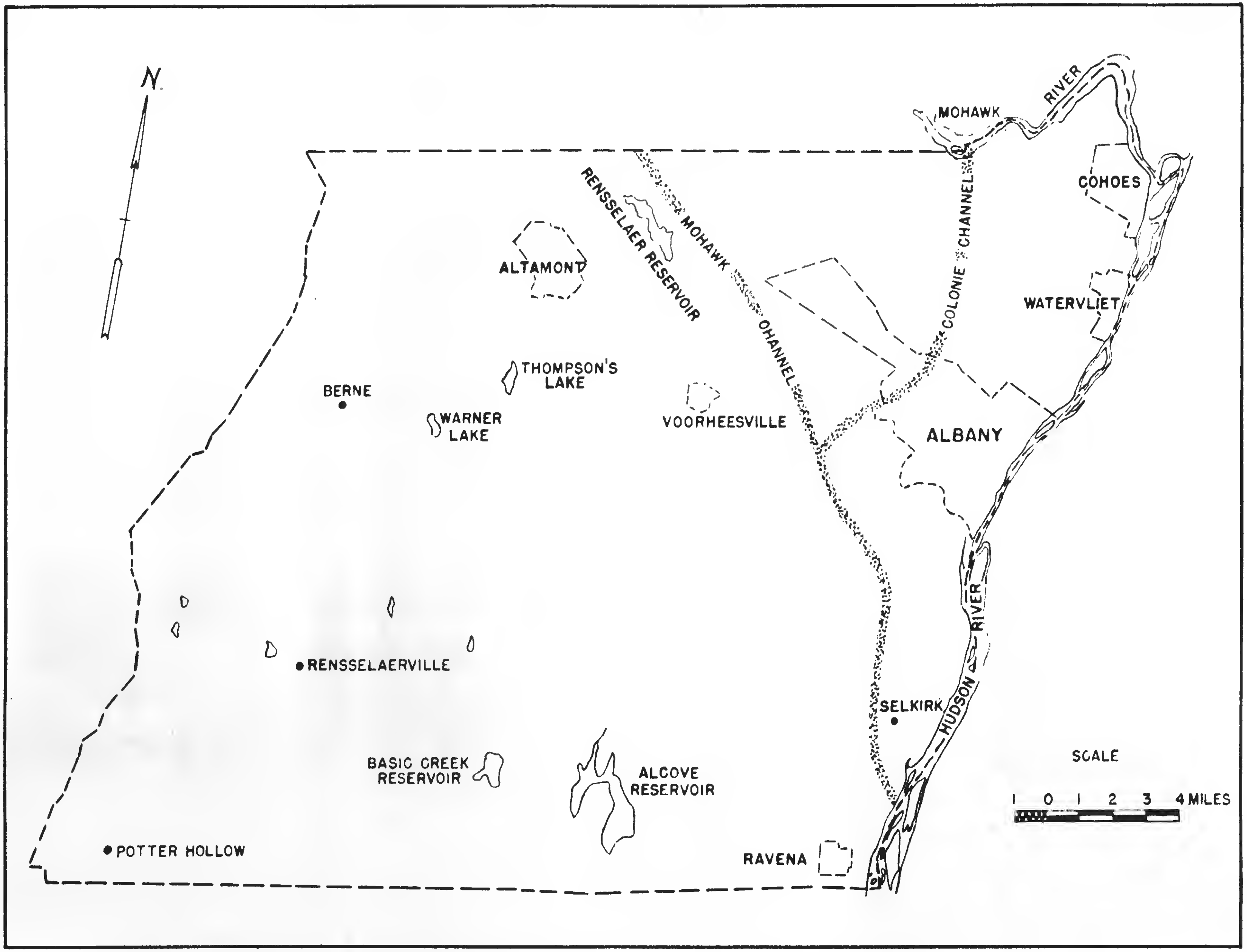

Figure 4.—Preglacial channel of the Mohawk River in the Albany area (after Simpson).

is therefore difficult to determine, but Reudemann[14] has estimated it to be at least 3,000 feet. It underlies a large heavily populated area in the county and this, coupled with the generally poor water-bearing qualities of the overburden has resulted in its widespread use.

Schenectady formation.—The Schenectady formation consists of black and gray argillaceous shales interbedded with grits and sandstones of variable texture. This formation is over 2,000 feet thick,[15] and the whole sequence consists of uniformly alternating beds of shale and sandstone. The sandstone beds range up to 15 feet in thickness and, under the name of "bluestones", formerly were much quarried for crushed rock and building stones. The Schenectady formation underlies a large part of the northwestern part of Albany County and has been tapped by many wells. The yield of each well is small, however, and in several places "dry" wells have been reported.

Brayman shale and Indian Ladder formation.—The Indian Ladder formation is over 400 feet thick[16] but crops out in only a narrow area along the Helderberg escarpment in the vicinity of New Salem and Knox. The lower part of the formation consists of dark-colored argillaceous shales and thin beds of calcareous sandstone. The upper part is composed chiefly of massive beds of sandstone interbedded with dark shales and occasional layers of limestone. The overlying Brayman shale, a greenish sandy shale containing much iron pyrite, crops out in only a few places in the Helderberg region in Albany County and reaches a maximum thickness of only 9 feet.[17] The Indian Ladder formation and the Brayman shale are both restricted in areal extent and are unimportant as aquifers.

Rondout and Cobleskill limestones.—The Cobleskill limestone is a heavily bedded, fossiliferous limestone, in part consisting largely of shell fragments and in part of impalpable waterlimes. There is just one small area of outcrop in the western part of the county and the formation there is only about 5 feet thick[18]. It is overlain by the Rondout limestone, a drab-colored impure magnesian limestone having some shaly intercalations. It is characterized in some places by pentagonal mudcrack structures, which indicate exposure while the beds were drying. In Albany County the Rondout crops out in the Helderberg region in only a few places and attains a maximum thickness of 14 feet[19]. Because of their small areal extent and thinness, both the Cobleskill limestone and the Rondout limestone are unimportant as sources of ground water. The Rondout, however, because of its position at the very base of the Helderberg cliff and its tendency to form caves, has become the formation through which many springs issue.

Manlius limestone.—The Manlius limestone is a thin-bedded, dark-blue limestone. Its layers range from 1 to 3 inches in thickness and weather to a characteristic light color. The formation is remarkably hard and resistant and, together with the overlying Coeymans limestone, forms the Helderberg cliff (fig. 2). Although extremely hard, the Manlius is subject to solutional activity which, particularly at the contact plane with the Coeymans, has resulted in the formation of numerous caves. The thickness of the formation has been placed at 45 feet by Goldring,[20] but because it is largely confined to the rugged portion of the Helderberg region the Manlius has been tapped by only a few wells.

Coeymans limestone.—The Coeymans limestone is a massive bluish-gray, coarse-grained, limestone which carries occasional shale partings and thin lenses of chert. It weathers to a characteristic light-gray color and is in large part composed of shell fragments. Though it is not subject to solutional activities as much as are the Manlius and Rondout limestones, caves are frequently formed in the Coeymans. One of the better known is the Knox Cave, which is now open to the public. Because of its massive character, extreme hardness, and characteristic vertical jointing, the Coeymans is one of the major cliff-producing formations of the Helderbergs. It reaches a maximum thickness of about 60 feet in Albany County and, together with the Manlius, forms the lowest and most famous of the Helderberg cliffs. Like the Manlius, the Coeymans underlies only the more rugged sparsely populated Helderberg area and consequently has been tapped by only a few wells.

[14] Ruedemann, Rudolf, Geology of the Capital district: op. cit., p. 118.
[15] Goldring, Winifred, The Geology of the Berne quadrangle: op. cit., p. 57.
[16] Goldring, Winifred, Handbook of paleontology for beginners and amateurs, pt. 2: New York State Mus. Handbook 10, p. 212, 1931.
[17] Goldring, Winifred, Geology of the Berne quadrangle: op. cit., p. 77.
[18] Goldring, Winifred, ibid., p. 78.
[19] Goldring, Winifred, ibid., p. 82.
[20] Goldring, Winifred, Geology of the Berne quadrangle: op. cit., p. 84.

Kalkberg limestone.—The Kalkberg is a transition formation between the underlying Coeymans limestone and the overlying New Scotland limestone. It is darker in color and more fossiliferous than the Coeymans, and more siliceous and less shaly than the New Scotland. It is about 25 feet thick[21] and in the Helderberg region forms either a low terrace below the New Scotland or a small portion of the cliff above the Coeymans. It is unimportant as a source of ground water.

New Scotland limestone.—The New Scotland limestone, the least conspicuous and the most fossiliferous formation of the late Silurian and early Devonian limestone sequence, consists of thin-bedded, shaly limestones and calcareous shales. In fresh exposures the limestone has a dark bluish-gray color but weathers to a gray or gray-brown color. The New Scotland usually forms a gentle slope behind the cliff formed by the Coeymans limestone, and the thickness of the section is estimated to be about 100 feet[22]. Confined primarily to the sparsely populated mountainous Helderberg area, the New Scotland limestone is unimportant as an aquifer.

Becraft limestone.—The Becraft is a pure massive limestone which is typically very coarse-grained and composed largely of shells and shell fragments. It is light-colored, with pinkish and light-gray and, occasionally, yellow tints, but it darkens somewhat on weathering. In Albany County the Becraft attains a thickness of about 27 feet[23] and because of its massive character sometimes forms conspicuous ledges (fig. 2). The Becraft is subject to much solutional activity but, because of the thinness of the section, is unimportant as a source of ground water.

Alsen and Port Ewen limestones.—The Alsen limestone appears to be a modification of the Becraft in that it is less pure and finer-grained. It is dark blue-gray in color and often weathers to a buff color. The Port Ewen limestone consists of a series of shaly limestones carrying a fauna that is a mixture of New Scotland and Oriskany forms. Both the Alsen and the Port Ewen limestones, therefore, appear to be transitional beds. They appear in areas in the western part of the county and are of no importance as aquifers.

Oriskany sandstone.—The Oriskany is a very dark bluish-gray hard quartzose sandstone having a variable admixture of calcareous matter. In places where the rock is exposed the lime is dissolved, leaving a brown porous sandrock. In Albany County the formation has a maximum thickness of 4 feet[24], but because of its extremely resistant nature it often forms a broad level terrace from which the overlying soft Esopus shale has been removed. Because of its marked thinness the Oriskany sandstone is unimportant as a source of ground water.

Esopus shale.—This formation consists of a dark-gray grit or sandy shale of very uniform nature which readily crumbles to a gravel and weathers to a dark-brown color. Because of its soft character the Esopus forms a characteristic slope between the terraces on the harder Oriskany and Onondaga formations. In Albany County the Esopus shale attains a maximum thickness of nearly 120 feet, but it is of only minor importance as a source of ground water.

Schoharie grit.—The Schoharie is an impure siliceous limestone, dark bluish-gray in color, which weathers to a dark-buff or brown porous sandstone. It merges in places with both the Esopus shale and the Onondaga limestone and is considered by some as a phase of either the Esopus or Onondaga. The formation attains a maximum thickness in Albany County of only about 20 feet[25] and is discontinuous in horizontal extent. For this reason it is unimportant as a source of ground water.

Onondaga limestone.—The Onondaga is generally massive in appearance and contains characteristic parallel layers of chert, particularly in its lower part. It forms the second great cliff of the Helderbergs and because the comparatively soft beds of overlying Bakoven shale have been eroded away, the Onondaga remains as a broad terrace in some places more than a mile in width. The formation attains a maximum thickness of about 100 feet and is particularly subject to solutional activity, which creates sinks and underground caves. Thompsons

[21] Ruedemann, Rudolf, Geology of the Capital district, op. cit., p. 51.
[22] Goldring, Winifred, Guide to the geology of John Boyd Thacher Park (Indian Ladder region) and vicinity: op. cit., p. 67.
[23] Goldring, Winifred, ibid., p. 72.
[24] Goldring, Winifred, Handbook of paleontology, op. cit., p. 380.
[25] Goldring, Winifred, Geology of the Coxsackie quadrangle: op. cit., p. 224.

Lake occupies part of one of these sinks. Because it forms a broad, flat terrace which usually provides good farming land, the Onondaga has been tapped by many wells and constitutes a fairly important aquifer.

Bakoven shale.—This formation, formerly termed the "Marcellus shale", is the basal formation of the Hamilton group in Albany County. Typically, it is a black pyritiferous fissile shale. The Bakoven attains a thickness of about 200 feet[26] in Albany County and forms gentle slopes in the hillside above the terrace formed on the Onondaga. These slopes are used chiefly for grazing land and the Bakoven shale has been tapped by only a few wells.

Mount Marion formation.—The Mount Marion formation consists of argillaceous sandstones and sandy shales which are dark blue-gray in color when fresh, and heavier sandstones. The heavier sandstones predominate in the higher horizons and the entire formation tends to weather to a brownish color. The formation is over 1,400 feet thick[27] and underlies much of the south and west-central part of the county. The formation, therefore, constitutes one of the more important bedrock aquifers in Albany County.

Ashokan formation.—The Ashokan formation consists of tough laminated arkosic flagstones (bluestones) containing interbedded shales which weather red or brown. The sandstones are generally coarse-grained and range from thin beds to flags thick enough to be quarried. The maximum thickness of the beds in Albany County is nearly 350 feet,[28] but they crop out in only a small area. The Ashokan has been tapped by only a few wells in Albany County.

Kiskatom formation.—These are continental "red beds" which were formerly regarded equivalent in age to the Oneonta sandstone. They are coarse dark-gray to green flaggy sandstones with intercalations of red and green shales. Red sandstones are characteristic but thin beds of dark-gray or black shales appear in places. The thickness of the section is over 1,000 feet[29] in Albany County, and as the formation underlies much of the southwestern part of the county, it furnishes ground water to many wells.

Onteora formation.—The Onteora formation consists of red sandstones and shales quite similar in character to the red beds of the Kiskatom formation. They contain, however, a larger proportion of sandstone and also several layers of conglomerate. The thickness of the Onteora has been estimated to be about 1,150 feet[30], but the formation occurs in only a small part of the southwestern portion of the county and is therefore of little importance as a source of ground water.

Glacial deposits.—Glacial deposits mantle much of the region, and constitute the most important source of ground water in Albany County. The glacial deposits may be divided into two major groups, till and outwash. The approximate areal distribution of till and outwash in Albany County is shown in figure 5. Till is a heterogeneous mixture largely of unstratified material ranging in size from clay to boulders. It consists of debris dropped by the glaciers and it may assume the form of ground moraine, which is a relatively thin widespread layer of till; drumlins, which are rounded hills composed of till; and lateral and end moraines, which are masses of till deposited at the sides and end of a glacier respectively. All these land forms, containing more or less similar materials, are represented in Albany County. Till usually yields only small quantities of ground water and wells tapping it are generally suitable only for home or farm use.

Outwash consists of sorted material that has been deposited directly by glacial streams, or has been deposited in standing water of glacial age, or has resulted from the reworking of unsorted deposits by moving water. Outwash deposited by streams emanating from glaciers often varies widely in character because the velocity and volume of the streams themselves varied according to the rate of melting of the ice. These deposits are generally cross-bedded and show marked gradations in size, ranging from silt through coarse gravel. In places, outwash is underlain, overlain, or intermingled with till deposits. The coarser beds of outwash may yield large supplies of ground water.

The outwash deposits laid down in standing glacial meltwaters are generally well sorted but usually consist of relatively fine materials such as sand, silt, or clay. Albany

[26] Ruedemann, Rudolf, Geology of the Capital district: op. cit., p. 68.
[27] Goldring, Winifred, Geology of the Coxsackie quadrangle: op. cit., p. 254.
[28] Goldring, Winifred, ibid., p. 269.
[29] Goldring, Winifred, ibid., p. 277.
[30] Chadwick, G. H., Geology of the Catskill and Kaaterskill quadrangle, Part 2, N. Y. State Mus. Bull. 336, p. 126, 1944.

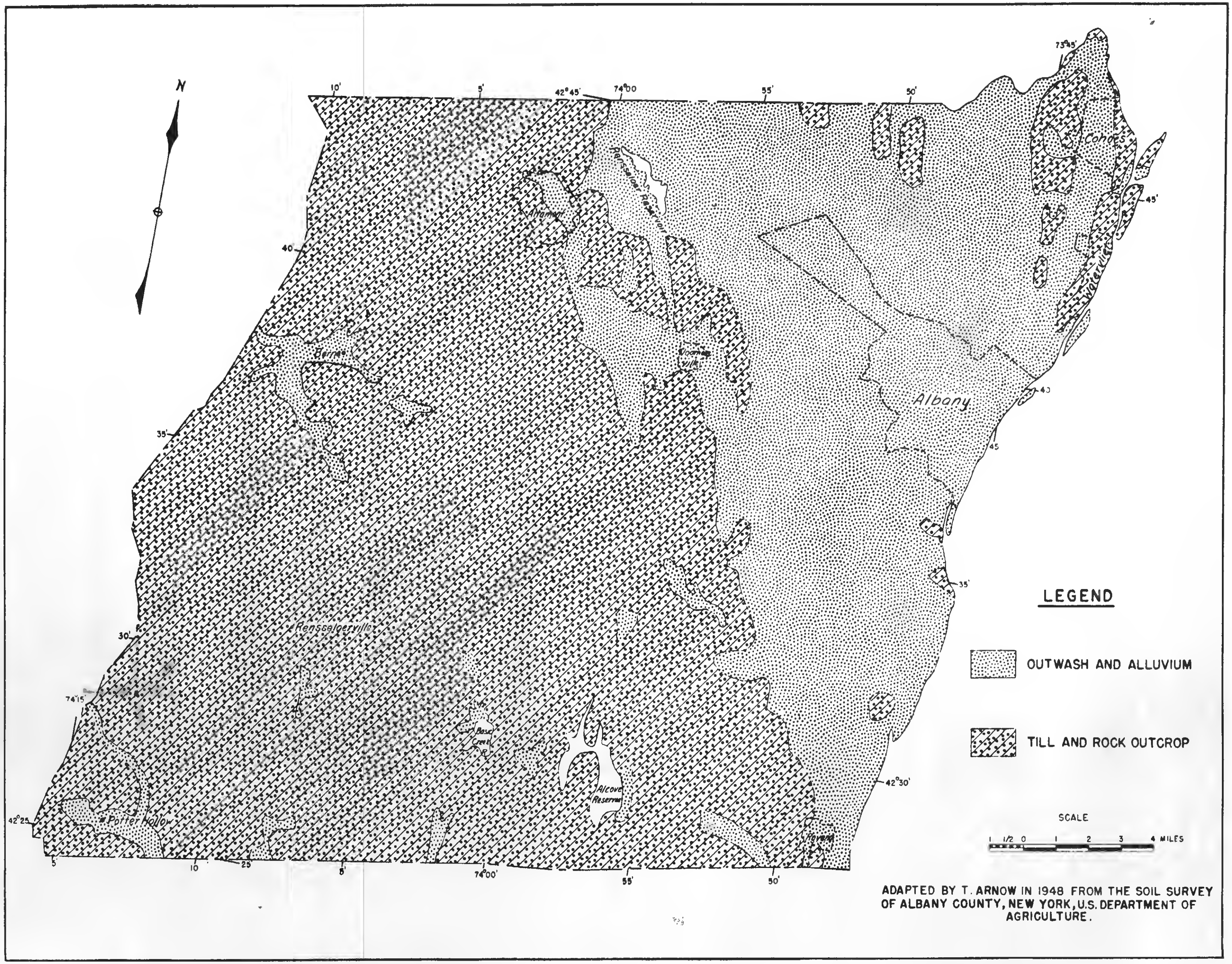

Figure 5.—Approximate areal distribution of till and outwash deposits in Albany County, New York.

County is particularly rich in this type of deposit. According to Woodworth,[31] material was laid down as a huge delta in a lake which covered the entire plains region west of Albany during the time of the retreat of the Pleistocene ice sheet. Woodworth named this body of water Lake Albany. Cook,[32] however, believes that rather than one large lake there existed a series of smaller lakes created by temporary barriers during the stagnation of the ice in place, and that the clays and fine sands accumulated to various summit levels in these lakes. The highest level of deposition, according to both, is about 320 feet above sea level. Mostly clay was deposited south and southwest of the city of Albany, but northward the clays in the upper section disappear and deposits of sand appear (see table 4, logs for A99 and A272), and farther north, in Schenectady County, gravel beds overlie the clay deposits.

The thickness of the outwash deposits varies widely, a maximum of 370 feet being penetrated by well A362 in the buried Mohawk Channel. Outwash deposits, particularly the gravels, are generally excellent aquifers and constitute the most important water-bearing horizons in the county. Substantial deposits of gravel are situated in the Mohawk and Colonie Channels (fig. 4), in a triangular area near Voorheesville and New Salem, in a small area at Medusa, and in a larger area near Kenwood and Glenmont. Thinner deposits are situated in the valleys of Catskill Creek, Fox Creek, and Switz Kill.

Alluvium.—The most recent deposits in Albany County are the alluvial clays, silts, sands, and gravels found associated with the larger streams. The deposits are limited in areal extent and though in the Hudson River valley may attain a thickness of over 50 feet (see table 4, log for well A143), they are in most cases much thinner. If tapped properly by a modern, efficiently developed well, the alluvium will yield substantial quantities of water.

GROUND WATER

SOURCE

Ground water has been defined by Meinzer[33] as "that part of the subsurface water which is in the zone of saturation," but it is popularly regarded by the layman as the water that is obtained from wells and springs. Although it is pumped or issues from the ground, its source lies in the atmosphere, and essentially all ground water is derived from rain and snow. In almost all parts of the county the underground reservoirs are replenished directly from precipitation over the immediate area, but in the limestone region of the Helderbergs there is considerable underground movement before the water is returned to the surface. According to Cleland,[34] most of the ground water follows solutional cavities down the dip of the bedding planes of the limestone and emerges to the south, at Fox Creek east of Berne. It has been found, however, that a large quantity of water flows in the opposite direction and, emerges in springs from under the Helderberg cliff. Several of these springs are used as public water supplies for Voorheesville (A11Sp and A12Sp) and one was formerly used as part of the Bethlehem public supply (A14Sp). In the remainder of the county there is little large-scale, long-distance movement of water underground and the local precipitation serves as the supply for most wells and springs.

That the precipitation is sufficient to meet all demands is shown by the fact that an inch of rain will yield more than 17 million gallons of water per square mile. Thus the average rainfall of 37 inches contributes annually about 630 million gallons of water to each square mile of land surface in Albany County. This, in turn, indicates that a total of about 335 billion gallons of water falls on Albany County each year. Of this, part runs off directly in the streams, a part evaporates or is transpired by plants, and the remainder seeps into the ground and recharges the water table. Although the supply of ground water generally varies directly with the amount of precipitation, other factors also control the rate of recharge. If the temperature is very high the rate of evaporation materially decreases the potential supply of ground water. If, on the other hand, the temperature is so low that the ground is frozen, an unusually high percentage of the water, finding its descent blocked,

[31] Woodworth, J. B., Ancient water levels of the Champlain and Hudson Valleys: New York State Mus. Bul. 84, p. 175, 1905.

[32] Cook, J. H., Glacial geology of the Capital district: op. cit., p. 196.

[33] Meinzer, O. E., The occurrence of ground water in the United States: U. S. Geol. Survey Water-Supply Paper 489, p. 38, 1923.

[34] Cleland, H. F., Post Tertiary erosion and weathering: Am. Jour. Sci. 5th ser., vol. 19, p. 289, 1930.

runs off directly into the streams. During the growing season the demands of vegetation, both natural and cultivated, make heavy inroads into the ground-water supply.

OCCURRENCE

All rocks, regardless of their density, contain some pore spaces. Only those pores which are large enough, however, can release water to springs and wells tapping the rock. The amount and size of the openings vary with the character of the rock, and the yields of wells are therefore directly related to the type of rock tapped. The percentage of total rock volume that is occupied by open spaces is a measure of the porosity of a rock. According to Meinzer,[35] the porosity of a sedimentary deposit depends chiefly on (1) the shape and arrangement of its constituent particles, (2) the degree of assortment of its particles, (3) the cementation and compaction to which it has been subjected since its deposition, (4) the removal of minerals through solution by percolating waters, and (5) the fracturing of the rock, resulting in joints and other openings.

Although the porosity of a rock indicates the total volume of pore space available for storing water, it is necessary to use a term, called specific yield, that indicates the amount of water that will drain out of a rock because of the action of gravity. The specific yield of a rock or soil, with respect to water, is the ratio, expressed as a percentage, of (1) the volume of water which, after being saturated, it will yield to gravity to (2) its own volume. It is a measure of the water that is free to drain out of a material under natural conditions. The value for the specific yield of a rock or soil will be less than the value for porosity since capillary forces will prevent the draining, by gravity, of all the interstices or pore spaces. In addition to specific yield, the term hydraulic permeability must be introduced to indicate the capacity of the rock or soil for transmitting water under pressure. This term, however, is useful primarily when dealing with uniform, unconsolidated deposits, and should be used cautiously (if at all) when the aquifer is an indurated rock which transmits water only through fractures or solution planes. In general, the smaller the interstices of a material the lower will be its specific yield and hydraulic permeability. Thus, clays and silts, which usually have higher porosities than sands or gravels, will yield considerably less water.

The water table is an irregular plane immediately below which all rocks are saturated with water. The source of this water is rainfall which percolates down from the surface. The water table is influenced by but does not exactly reproduce the configuration of the surface topography. Depth to the water table, below the land surface, varies seasonally and annually with variations in precipitation, runoff, withdrawals by wells, temperature, and other related factors.

Under normal water-table conditions water will rise in a well to a height corresponding to that of the water table. When a water-bearing bed is overlain by impermeable beds which serve to confine the water under pressure, an artesian system is created and water will rise in the well to a level other than that of the water table, and in some cases will flow out of the well.

Four percent of the well records obtained for Albany County describe flowing wells developed in both consolidated and unconsolidated deposits that are overlain by impermeable materials of sufficient thickness and lateral extent to confine the water under pressure. Each flowing well represents purely limited local conditions, as there appears to be no evidence of any widespread artesian aquifer in the county. Wells A374, A375, and A376, however, located within a short distance of each other and all drawing their supply from the Mount Marion formation, indicate the existence of a small basin throughout which artesian conditions exist. There were no other flowing wells reported from the Mount Marion formation. A445, a flowing well from the Onondaga limestone, represents an unusual case. The overburden there is reported as 10 feet of earth which does not appear to be sufficient to create artesian conditions. The well may encounter a solution channel through which the water is flowing down dip after having entered the formation at a higher elevation to the northeast. The difference of head would account for the flowing well.

Normanskill shale.—The rocks of this formation are extremely dense and are practically impervious. They do, however, contain many joint, cleavage, and bedding planes that yield small supplies of ground water. These openings are sometimes subject to calcina-

[35] Meinzer, O. E., The occurrence of ground water in the United States: op. cit., p. 3.

tion which tends to reduce the yield of the formation. Records for 14 wells in the Normanskill indicate an average yield of only 4 gallons per minute. Two other wells, A320 and A367, are reported to have yielded 30 and 40 gallons per minute, respectively. Such yields, however, seem to be exceptional. Records for 26 wells ending in the Normanskill show an average rock penetration of 92 feet, an average depth of 169 feet, and a range in depth from 38 to 301 feet. Pumping tests at four wells show an average specific capacity of 0.1 gallon per minute per foot of drawdown. The joints and other openings in the Normanskill tend to diminish in size and pinch out with depth, and it is generally advisable to discontinue drilling if a suitable supply of water has not been obtained after penetrating about 200 feet of the formation.

Snake Hill formation.—This formation is similar to the Normanskill shale in that it also is dense and nearly impervious, and contains recoverable ground water only in joint, cleavage, and bedding planes. The Snake Hill formation differs from the Normanskill, however, in that it contains beds of sandy limestone which are believed to be responsible for the larger yields occasionally obtained from the Snake Hill. Twenty-four wells in the Snake Hill formation for which figures are available show an average yield of 16 gallons per minute. Of these, however, four were reported to be dry and five yielded more than 25 gallons per minute. A test at well A352 caused a drawdown of 130 feet after 20 hours of pumping at 30 gallons per minute, which indicated a specific yield of about 0.2 gallon per minute per foot of drawdown. Thirty-seven wells ending in the Snake Hill show an average rock penetration of 152 feet, an average total depth of 205 feet, and a range in depth from 45 to 480 feet.

The location of joints and bedding planes in rock cannot be accurately predicted. It is difficult, therefore, to forecast yields in advance of drilling, and the success or failure of a well depends largely upon the number and size of the fissures encountered. As in the Normanskill, the possibility of increasing the yield of wells in the Snake Hill decreases with depth and very deep drilling is generally inadvisable. For example, wells A9, A115, and A130, which were all dry, were replaced by wells A10, A116, and A131, which were drilled within 200 feet of the original wells and all of which yielded water from shallower depths.

Schenectady formation.—The rocks of this formation, like those of the Snake Hill and Normanskill formations, are dense and relatively impervious. They yield small amounts of water, however, from joint and bedding planes. Figures available for 16 wells in the Schenectady formation show an average yield of 2.6 gallons per minute. Only two of the wells yielded over 5 gallons per minute and five were reported completely dry. A test at well A459 showed a 97-foot drawdown after 20 minutes of pumping at 1.5 gallons per minute, indicating a specific yield of 0.02 gallon per minute per foot of drawdown. Thirty-four wells ending in the Schenectady formation show an average rock penetration of 94 feet, an average total depth of 125 feet, and a range in depth from 12 to 400 feet. As in the Normanskill and Snake Hill formations, the rocks of the Schenectady formation tend to become more compact with depth and it is generally regarded inadvisable to continue drilling to great depths.

Late Silurian and early Devonian limestones.—Included in this sequence are the Rondout, Manlius, Coeymans, Kalkberg, New Scotland, and Becraft limestones. On the whole they are dense impervious rocks having little pore space available for storage or transmission of water. A series of open joint and bedding planes, however, permit some movement of ground water. Records have been obtained for only seven wells in these limestone formations and yields for these average about 4 gallons per minute. The average depth of these wells is 112 feet. A test at well A348, which is ended in the Coeymans, showed a drawdown of 55 feet after 20 minutes of pumping at 3 gallons per minute.

The joint planes in the limestone have been developed in two main groups, one trending northeast-southwest and the other northwest-southeast. There are also several sets of minor fissures. The joint and bedding planes have[36] been enlarged by solutional acitivity and in places form broad, deep fissures. Caves and sinkholes also have been developed, resulting in small-scale karst topography. According to Newland,[37] the caves may have been formed by ground water flowing along and enlarging the joint systems. Much of this water percolates down through the limestone formations and issues from the Rondout limestone at the base of the lower Helderberg cliff. The uniform line of springs issuing from the base of the cliff is

[36] Goldring, Winifred, Geology of the Berne quadrangle: op. cit., p. 98.
[37] Newland, D. H., as quoted in Goldring, Winifred, Geology of the Berne quadrangle: op. cit., p. 97.

caused by the highly impervious Brayman shale which underlies the Rondout and prevents further descent of the water.

Esopus shale.—The rocks of this formation are very dense and, like the limestones of the area, are incapable of transmitting water through the body of the rock itself. They are traversed, however, by an extensive system of joints. Yields reported for seven wells ending in the Esopus range from 2 to 40 gallons per minute, the average being about 20 gallons per minute. Four wells ending in the Esopus shale have an average rock penetration of 83 feet. Nine wells which pass through the Onondaga limestone and end in the Esopus show an average rock penetration of 160 feet. As is the case with the older formations, yields from the Esopus depend largely upon the number and size of fissures encountered. Yields from wells tapping the Esopus, high in comparison to those obtained from associated limestones, are probably due to the more extensive jointing system developed in the shale.

Onondaga limestone.—Like the other formations of the region, the Onondaga limestone is a dense impervious rock which transmits water only through joint and bedding planes. The joints appear to trend in the same direction as those in the lower part of the late Silurian and early Devonian limestone sequence. The Onondaga is also subject to solutional activity and an extensive underground drainage, including caves, sinkholes, and broad solution channels, has been developed. Karst topography on a fairly broad scale exists over the area underlain by the Onondaga.

Yields from wells tapping the Onondaga can be expected to vary considerably because of the large variation in size of the solution channels. Records are available for only eight wells and four of these show yields of 1, 3, 4, and 20 gallons per minute. The relatively large yield of well A445, which penetrates only 33 feet of rock, suggests it has intersected at least one sizable solution channel. The wells ending in the Onondaga have an average rock penetration of 72 feet, an average depth of 116 feet, and a range in depth from 43 to 225 feet. A test at well A429 showed a 60-foot drawdown after 30 minutes of pumping at the rate of 1 gallon per minute.

Hamilton group.—The Bakoven shale and the overlying sandstones and shales of the Hamilton group are all dense impervious rocks which transmit water only through joint and bedding planes. Reported yields for 12 wells tapping these rocks show an average yield of 7.5 gallons per minute, with the maximum being 16 gallons per minute. The average rock penetration of 45 wells reported to tap the Hamilton strata is 88 feet, the average depth is 105 feet, and their depths range from 8 to 552 feet. According to Parker,[38] the Hamilton is traversed by two major intersecting sets of joints which trend northeast-southwest and northwest-southeast. These joints have not been enlarged by solutional activity and consequently do not form as continuous underground conduits as are sometimes found in the underlying limestones. This fact is borne out by operational experience at the dam for the Alcove Reservoir (city of Albany water supply), part of which rests upon sandstones of the Hamilton group. Since the completion of the dam in 1930 there has been no evidence of any appreciable loss of water to the rock formations.

Glacial deposits.—Of the wells in Albany County for which records have been obtained, over 55 percent draw water from glacial deposits. Data are available for 76 drilled wells, 73 dug wells, and 54 driven wells which tap the Pleistocene drift. The thickness of the glacial deposits varies within wide limits. The till deposits which cloak the mountainous region in the western part of the county are comparatively thin. In contrast, more than 100 feet of outwash has been penetrated in the valleys of this region. On the plains west of the city of Albany the deposits thicken considerably and a maximum of 370 feet of outwash is known to occur in the buried valley of the Mohawk River.

Till, in one form or another, although relatively impervious, yields sufficient water to wells for general household and farm purposes. Ground water is usually pumped from the till by means of dug wells, which offer the advantage of a large infiltration surface, a large storage area, and comparatively inexpensive construction cost. Records for 25 wells dug in till have been collected in Albany County, and all appear to have furnished adequate supplies of water for household use, except in times of extreme drought. Wells of this type are gradu-

[38] Parker, J. M., Regional systematic jointing in slightly deformed sedimentary rocks: Geol. Soc. America Bull., vol. 53, p. 387, March 1942.

ally being replaced by deeper drilled wells wherever the till is underlain by more permeable rocks. In some areas, however, the underlying rocks are less permeable than the till and it is not possible to tap more abundant aquifers.

The glacial clays are even more impervious than till. A test on A169, a dug well 3 feet in diameter and 22 feet deep, loosely stoned up in blue clay, resulted in a yield of only about half a gallon per hour. Wells of very large diameter are needed to extract even a small supply of water from glacial clays. In many cases such wells serve merely as an auxiliary to a rain-water cistern supply.

Sands of lacustrine origin, though very fine in texture, are much more permeable than the clays of like origin. The sands yield water readily to dug wells and also permit recovery from driven wells of quantities sufficient for household use. Records are available for over 50 driven wells, all between 1¼ and 2 inches in diameter and averaging about 25 feet in depth. A test at well A363, 21 feet deep and 1¼ inches in diameter, resulted in a yield of 50 gallons per minute after 36 hours of pumping, with only a small drawdown.

The coarser glacial stratified deposits are the most prolific aquifers in the county. Data for 17 wells that tap sand or gravel deposits indicate an average yield of 30 gallons per minute and an average depth of 162 feet. Most of these wells are 6 inches in diameter and have not been screened or developed. Yields of 21 other wells which have been screened and thoroughly developed show an average of 300 gallons per minute. These average 10 inches in diameter and about 114 feet in depth. Pump-test data for 12 of them shows a large specific capacity, an average of 175 gallons per minute per foot of drawdown, and a maximum of 931 gallons per minute per foot of drawdown (well A82). The advantages of properly developing a well are thus clearly obvious.

Alluvium.—The sand and gravel deposits of Recent origin are also excellent aquifers but are tapped by only a few wells. Three 10-inch wells, A143, A144, and A145, obtain water from alluvial deposits along the Hudson River and have reported yields of 350, 100, and 75 gallons per minute, respectively. The maximum thickness of alluvium reported was 58 feet. Although river infiltration is not definitely established at those wells mentioned above, there is the strong possibility that wells tapping alluvial deposits in the stream valleys may induce considerable recharge from the nearby streams.

RECOVERY

Types of wells[39]

Meinzer[40] has defined a well as "an artificial excavation that derives some fluid from the interstices of the rocks or soil which it penetrates, except that the term is not applied to ditches or tunnels that lead ground water to the surface by gravity."

Well construction is probably one of the oldest trades or arts known to man. The history of its development may be traced from the primitive activities of the Egyptians, 5,000 years ago, up through the improvements introduced by early Chinese engineers, to the early well-construction work performed in Europe and the United States. The majority of wells constructed in the United States, up to and for some years after the Civil War, were dug wells cased with brick or stone or any other material that would prevent the excavation from caving in. Settlement of the Middle West, however, created an early need for additional water supplies as the creeks and ponds that were first used by the pioneers became overtaxed. The drilled well thus came into common use as a relatively inexpensive means of obtaining water in a short time.

Wells are commonly classified by types according to the particular method of construction. Thus five general types are recognized; namely, *dug, bored, jetted, driven,* and *drilled.* Each has particular advantages that make it more desirable than the others under certain local conditions. The type names themselves suggest the type of construction of the wells. Wells of the first four types usually are put down to relatively shallow depths (less than 50 feet) and often are constructed with hand tools. The fifth type, the drilled well, is probably the most important type of well in use today.

[39] In assembling data for this section frequent reference was made to War Dept. Tech. Manual TM 5-297, Well drilling, Nov. 29, 1943.

[40] Meinzer, O. E., Outline of ground-water hydrology, with definitions: U. S. Geol. Survey Water-Supply Paper 494, p. 60, 1923.

Briefly, a dug well, as the name implies, usually is excavated with hand tools and lined with brick, stone, steel, wood cribbing, tile, or other suitable material. The diameter is seldom less than 3 feet and may be as great as 80 feet or more, depending upon the yield that is desired and the rate at which the water-bearing strata will yield water.

A bored well is constructed with an earth auger of either the hand or power-operated type, and is cased with standard well casing. It is used where speed of construction and economy of material are essential and where relatively small quantities of water are available at shallow depths in such unconsolidated formations as glacial till or alluvial valley deposits. The diameter of a bored well is not great, as it is limited by the diameter of the auger that can be used.

A jetted well is constructed where no rocks or boulders are present. It is particularly adapted to localities where water occurs in sand at shallow depths. It is a simple and dependable type of well that can be constructed rapidly with hand tools without recourse to bulky power tools. The basic method of construction involves "washing" a casing vertically into the ground until it has reached a point below the water table. The well pipe, with a suitable screen attached is then lowered into the casing and the casing is pulled out, leaving the well pipe and screen in the ground in position for pumping.

A driven well is adapted to localities where no rock is present and where the water-bearing material will yield at least moderate supplies of water. As the name suggests, it is constructed by driving a pointed screen called a "drive point", attached to a sufficient length of pipe, into the water-bearing formation.

Drilled wells constitute the most important and most widely used type of wells. The two principal methods of drilling are the percussion-tool or spudding method and the hydraulic-rotary method. Each method has its own appropriate use under certain conditions. The percussion or cable-tool method involves construction of a hole by the percussion and cutting action of a clublike, chisel-edged drilling bit that is alternately raised and dropped. The formation through which the hole is being drilled is thus broken into small fragments that become churned and mixed into a sludge. At intervals the sludge is removed from the hole with a bailer or a sand pump. In hard rock the hole usually is drilled without casing but in unconsolidated materials well casing is repeatedly driven down so that only a few feet of open drill hole extends below it.

The hydraulic-rotary method involves rotating suitable tools that cut, chip, and abrade the rock formations into small particles. Special drilling mud is pumped down the hollow rotating drill rod, out through the drill bit attached to the lower end of the pipe, and returned to the land surface through the annular space between the drill rod and the walls of the hole. As the mud returns to the land surface it not only carries along the drill cuttings from the hole but seals the formations that have been penetrated, thus preventing caving. Generally the well casing is lowered and set into place in one continuous operation after the well has been drilled to the required depth.

In the foregoing paragraphs five basic types of wells have been briefly described. In recent years, however, two new types of wells have been developed that stem from one or more of the five basic types.

The gravel-wall or gravel-packed well is constructed after first drilling a hole by either the cable-tool or hydraulic-rotary method. It is most commonly constructed with hydraulic-rotary tools and is designed for use where the water-bearing material is composed of fine-grained sand that otherwise would require exceedingly fine screen openings. Although several methods of construction are possible, they are all designed to produce an envelope of uniform-sized gravel around the well screen. This permits use of larger-sized screen openings and consequently the recovery of a larger amount of ground water from the formation. The gravel envelope must be correctly sized, however, and extensive enough to permit the building up, around the screen, as the well is pumped and developed, of a graduated wall of assorted sand and gravel.

The multiple horizontal collector type of well was developed and first used just prior to World War II. The emergency nature of the water-supply requirements for many war industries prompted the construction of this type of well, during the war years, at many sites where other types of wells would not have produced the desired yield. A multiple horizontal

collector well is constructed by sinking a reinforced concrete shaft or caisson, having an inside diameter of about 15 feet, down through the water-bearing strata and sealing it at the bottom with a heavy reinforced concrete plug. Perforated screen pipes, commonly 8 inches in diameter, are then jacked out horizontally into selected portions of the water-bearing stratum or strata for distances as great as 300 feet. The number of these "radial well points" is based on the capacity of the water-bearing formation or the yield desired. Obviously this type of well is especially adapted for use where the water-bearing formation consists of a thin layer (or thin layers) of sand or gravel that could be tapped only by a well creating an exceedingly low drawdown. This type of well is also adapted for use at sites adjacent to rivers or lakes which are underlain by materials that will permit infiltration of water to the radial collectors of the well.

The types of wells available and in use today, therefore, are sufficiently varied to insure successful recovery of ground water from most any type of water-bearing formation that test-well drilling may locate.

Well-drilling equipment and pumps

Early development of equipment used in drilling water wells was stimulated, in the United States, primarily by experience gained in drilling to great depths for oil and gas. In recent years, however, development has been spurred by the rapidly expanding requirements of the water-supply industry itself. As the fund of general information concerning geology and the occurrence of ground water in the United States expanded, industries and municipalities probed deeper and deeper into the earth in search of satisfactory ground-water supplies. In Texas water-bearing sands have been successfully tapped at depths in excess of 2,000 feet, and on Long Island, New York wells tap water-bearing strata at depths in excess of 1,000 feet.

In many parts of the United States a single water-bearing stratum at a given site will not furnish an adequate supply of water. This would immediately fix and perhaps drastically limit the extent to which the area could be developed were it not for the fact that by modern methods of exploratory drilling, and subsequent precise placing of well casing and screens, the low individual yields of several water-bearing strata, located at different depths below the land surface, may be combined in a single well to permit more complete utilization of the total supply available at the site.

Screens in use today in sand or gravel wells represent radical departures from the early types of screens. Former designs were predicated upon the assumption that the size of individual openings should be small enough to exclude from 60 to 80 percent of the fine-grained materials in the water-bearing aquifer. This practice resulted in unreasonably small amounts of water that could be recovered from an aquifer, clearly indicating an inefficient type of screen. Furthermore, the efficiency often declined with use because the screen openings usually consisted merely of square openings in wire mesh or some convenient pattern of round holes in the steel casing. A single grain of sand was sufficient to clog either type of opening, thus reducing the effectiveness of the screen. Accordingly, design refinements were repeatedly made until the present types of screens were evolved. These screens generally have openings calculated to exclude only about 30 percent of the fine-grained materials in the aquifer. Instead of round or square holes the openings are sharp-edged slots, widening abruptly toward the inside. The advantages of this type of opening should be obvious. A single sand grain cannot clog a slot because it can make contact at only two points, and it is only necessary for a grain to pass the sharp outer edges of the slot in order to be pumped out with the water.

Construction of the gravel-walled type of well previously described has been made possible by the design of two general types of underreaming tools for enlarging the diameter of a drilled hole in the particular water-bearing stratum or strata selected for development. One type of tool consists primarily of a jetting device that removes the water-bearing formation by hydraulic means. The second type of tool is a mechanical reamer having blades that can be expanded to cut out the formation to the desired diameter.

Improved designs of "fishing" tools now assist the driller in overcoming some of the unavoidable accidents that occur in well drilling. Despite all precautions, tools are occasionally lost or become jammed in a well, causing delays varying from a few hours to several weeks. Any

devices that can be effectively employed to overcome these difficulties are therefore of considerable importance to the individual driller and to the entire waterwell-drilling industry.

Perhaps one of the most significant developments in the well-drilling industry was the motorization of drilling equipment, providing complete portability and permitting well-drilling operations to be conducted in areas that hitherto would have been either physically or economically inaccessible. As a corollary to the truck mountings for the drill rigs of today there has occurred a radical streamlining of the rigs themselves with considerable elimination of unnecessary weight. Improved designs permit easier and more rapid setting up of equipment with better handling of tools and casing. Thus the amount of footage drilled per machine-hour today is much greater than it has been in the past.

Accompanying the development of improved well-drilling supplies and equipment, permitting the construction of wells in progressively deeper-lying aquifers, there has been a continual challenge to pump manufacturers to design new and more efficient types of pumps capable of bringing water to the land surface not only from shallow levels (25 feet or less) but also from levels as much as several hundred feet beyond the suction limit. Many types and sizes of pumps are now available and space need not be taken here to describe them all. Several of the newest types, however, are worthy of consideration.

The ejector or jet pump,[41] developed for domestic and farm use, will operate satisfactorily in wells of relatively small diameter and under conditions where the water level is as much as 85 feet below the land surface. The pump is simple in construction, quiet in operation, and can be installed at some distance from the well. Its operation is similar to that of two pumps working together, one discharging into the other. With the pump primed and operating, water under high pressure is redelivered to the jet, or ejector nozzle, located at the lower (intake) end of a vertical Venturi tube set in the well near the lowest anticipated pumping water level. As the water at high velocity leaves the jet and passes through the Venturi tube a partial vacuum is created around the nozzle. Water from the well flows into this space from the suction pipe, and is caught up by the fast-moving stream. The mixture is carried into the expanded end of the Venturi tube, where the change from velocity head to pressure head is sufficient to lift the water to an elevation within reach of the vacuum created by the centrifugal pump at the top of the well. The centrifugal pump again develops a pressure head, delivering some of the water to a storage tank or a pneumatic pressure tank and returning the rest to the jet, to repeat the cycle.

The deep-well turbine type of pump is manufactured in a variety of models ranging in capacity from 30 to 7,000 gallons per minute. This type of pump cannot be efficiently used on wells smaller than 4 inches in diameter. A typical installation consists of a vertical motor at ground level, driving a vertical shaft that extends down into the well below the lowest anticipated pumping level. This shaft drives one or more impellers operating on the same principle as a centrifugal pump. Thus water from the well passes through a short length of suction pipe, enters the center or eye of the impeller, and is moved outward and upward by centrifugal force created by the rotation of the impeller within its housing. Because of limitations on the size and operating speed of a single impeller, it is often necessary to add additional impellers to develop sufficient total force or pressure to raise the water to the desired height. Turbine pumps using more than one impeller are called multistage pumps.

For wells in which the water level is more than 150 feet below the land surface the high-lift type of pump may be desirable. This pump is designed for relatively low capacities (30 to 60 g.p.m.) and requires a minimum well diameter of 4 inches. It operates on a principle that may be likened to the displacement of a piston in a cylinder of infinite length. A typical installation consists of a vertical motor at ground level, driving a vertical shaft that extends down into the well, below the lowest pumping level. This shaft drives a rotor of helical form inside a stationary housing or "stator" having a double helical form. These helices in reality are worm threads, so that the single worm thread of the rotor may be said to mesh with the double worm thread of the stator. As the rotor turns, water is squeezed ahead of the rolling action of the rotor along the inner surface of the stator. A pump of this type can be used to pump water from depths as great as 400 feet below the land surface.

The prospective well owner of today, therefore, can be assured not only that his well will be constructed to yield the maximum amount of recoverable ground water at the site, but

[41] Garver, H. L., Safe water for the farm: U. S. Dept. Agr. Farmers' Bull. 1978, September 1946.

also that some type of pump is available to fit the particular conditions at the site and to develop the safe yield of the well.

Local drilling techniques

Pertinent to the recovery of ground water for private, municipal, and industrial use is a study of the methods employed by local drillers and the status of development of drilling techniques in the light of improved types of wells and screens and improvements in drilling and pumping equipment. Within 50 miles of the area covered by this report there are more than 30 drilling firms currently engaged in well-drilling operations. The services they are equipped to perform range from construction of small-diameter driven or jetted wells to large-diameter (50-inch) wells, and the maximum depth to which any well can be drilled is about 3,000 feet. Supplementing these general services, about 10 of these drillers are equipped to install well screens and can install gravel-packed wells. One of these drillers has coring equipment and core-barrel equipment for collecting either rock samples or undisturbed soil samples.

A majority of all wells investigated in Albany County are drilled wells over 50 feet deep. Drilled wells in the area are of two general types, depending upon whether they penetrate bedrock or terminate in unconsolidated materials blanketing the bedrock. Casing for a well of the former type generally is driven to rock and an uncased hole is drilled into the rock to a depth sufficient to give the required yield of water. At some sites, however, the rock formation is so tight that the required amount of water cannot be obtained, no matter how deep the well is drilled. Casing for a well terminating in unconsolidated material may be left open where the water-beaing material consists of a coarse gravel, or it may be plugged and either slotted or fitted with a properly designed screen where the water-bearing material consists of fine gravel or sand. Wells finished in rock, or "rock wells" as they are often popularly called, present no serious constructional difficulties to the average driller. He may drill with confidence, knowing that when he reaches bedrock he will have a solid foundation upon which to seat his casing and that the finish of the well will then be merely a matter of drilling a sufficient depth of open hole in the rock. Occasionally, however, such a procedure will not result in a successful well. The joints and crevices in the bedrock may not be numerous or large enough to transmit the desired quantity of water to the well. With the casing firmly seated in the bedrock any possible increments to the well supply through drainage or seepage from the unconsolidated materials overlying the rock is effectively cut off. Well records indicate that often there is a thin layer of water-bearing gravel immediately overlying the rock. Thus the meager supplies of some rock wells conceivably might have been augmented by slotting or screening the casing just above the rock.

Often, however, economic consideration influences or dictates the type of well that is to be drilled. For example, if the quantity and quality of the ground water in the bedrock is satisfactory it may be more economical to ignore highly productive water-bearing sands or gravels whose development would require a screened well, and drill a "rock well" requiring no finishing.

Wells finished in unconsolidated materials require considerably more skill and judgment on the part of the driller. Not only must the water-bearing sands and gravels at the site be accurately located but the particular sand or gravel, or combination thereof, that will give the best yield must be selected. Sufficient sampling of the material in the selected aquifer must be done to permit determination of the proper-sized slots or screen openings, and considerable skill must be exercised in setting the screen at the proper level and sealing it off from undesirable waters at other levels.

Nearly all drillers in the area are equipped with cable-tool (percussion) well-drilling rigs. The few exceptions are drillers who operate light-weight portable-type rigs for installing small-diameter and relatively shallow driven or jetted wells. As noted previously, among the drillers equipped with cable-tool rigs only about 10 are equipped to install well screens and to construct gravel-packed wells. Most of the drilling in this area, therefore, has been limited either to "rock wells" or wells having an "open" finish in coarse gravels.

Methods of developing or improving yield

Development of a well has been defined[42] as the "post-drilling treatment—to establish the maximum rate of usable water yield." Local conditions often may suggest means of vary-

[42] War Dept. Tech. Manual TM 5-297, op. cit., p. 173.

ing the several standard development methods commonly used in screened wells drilled to tap sand or gravel aquifers. One local variation, already mentioned, is the possibility of increasing the yield of some rock wells by slotting the casing just above bedrock level. Wells are "developed" primarily to increase the yield at a given drawdown or to reduce the drawdown as much as possible when pumping at the designed rate.

Methods commonly used to improve the yield of a well include *surging, overpumping, backwashing,* and *acid treatment.* With the exception of the acid-treatment method, each is designed to wash the fine sand, silt, and clay from the water-bearing formation immediately surrounding the well screen and assist in the building up of a natural gravel wall around the screen. Thus water will enter the well more readily and the rate of yield per foot of drawdown (specific capacity) will be increased.

Surging a well is probably one of the best methods of development under the average conditions encountered in sand and gravel aquifers. The method utilizes some form of tight-fitting plunger that is operated up and down inside the well casing from a point about 15 feet below the static water level. This action surges the water in the sand or gravel formation, loosens the finer sand or gravel grains, and works them through the screen slots into the well, where they are periodically removed either by bailing or by pumping. The well is alternately surged and bailed (or pumped) until little or no more sand is pulled in through the screen. The surging method is particularly effective inasmuch as the forceful stirring of the water repeatedly disturbs the finer sand particles and prevent them from bridging against each other to close the voids or openings between the larger grains or pebbles.

The overpumping method of developing a well that taps a sand or gravel aquifer involves pumping it at a rate that creates excessive drawdown. This rate may or may not exceed the rate at which the finished well is to be pumped, depending upon the condition of the well at the time drilling is completed. The method is intended primarily to clear the well at or below the maximum rate at which it is capable of yielding water, and it cannot be used effectively to build up any graded envelope of gravel around the screen. If the well clears satisfactorily at a final rate considerably in excess of the desired rate of pumpage, it is safe to assume the well will not fail in regular service. If it does not clear, or if the desired rate of pumpage cannot be reached, then some more effective means of development must be used. The method is better suited for use at sites where it is anticipated that not much sand will be pumped during the development process.

Developing a well by backwashing may be accomplished by a number of different methods, each of which surges or agitates the water in the formation at the well, preventing "bridging" of the sand particles and removing a large portion of the finer material. If a pump is used three different operating procedures are possible to secure the desired results. (1) The pump may be operated at its highest capacity until maximum drawdown of the water level is obtained, whereupon it is then stopped, the water is drained rapidly out of the pump column, and the well is allowed to regain its original static water level. The process is repeated until no further improvement in yield is noted. (2) The pump may be operated to obtain maximum drawdown and then stopped and started alternately at short intervals. Thus the water level in the well is held down and frequently agitated in the formation adjacent to the well by the backwash of water in the pump column. (3) The pump may be operated until water begins to discharge at the surface. The pump is then stopped and the water allowed to drain from the column. The process merely agitates the water in the formation, and is repeated as many times as is necessary.

Backwashing may also be performed by pouring water into the well as rapidly as possible and then bailing vigorously with a sand pump or bailer. Where possible a more forceful method utilizes a watertight hose or pipe connection to the top of the well permitting water from a standpipe or pressure main to be forced down in large volume and under high pressure for 2 to 5 minutes. The connection is then removed and the well bailed vigorously.

Acid treatment of a well provides a means for regaining some of the yield that has been lost because of gradual incrustation of the well screen. All ground water is corrosive or incrusting to a certain degree, depending on the amount and kinds of substances it contains in solution. Under pumping conditions some of the salts normally held in solution in ground water may be precipitated on the well screen and on the gravel and sand grains adjacent to

the screen, owing to the sudden decrease in pressure as the water flows from the formation into the well. This is particularly apt to occur where the water contains carbonate or sulfate salts. If the screen is constructed of brass, bronze, or stainless steel these incrustations may be removed by introducing at the screen level a sufficient quantity of commercial hydrochloric acid (for carbonate or iron deposits) or sulfuric acid (for sulfate deposits) to create a 10- to 25-percent solution. This is allowed to stand for 1 to 2 hours; the well is then gently surged for several minutes and allowed to stand again for 2 hours or more. Finally the well is bailed clean and pumped for at least 1 hour. Depending upon the yield noted during this pumping period, the process may need to be repeated one or more times.

Other methods of improving or developing the yield of a well include dynamiting and combined surging and pumping through use of compressed air or surge blocks. "Dry ice" may be used to simulate surging or pressure effects through the bubbling action that occurs when it is submerged in the well. Local conditions will usually suggest, if not determine, the particular method of development that should prove most effective.

Recovery in Albany County

Ground water in Albany County is recovered principally by means of wells, comparatively few springs having been developed as sources of water supply. Of the records of wells collected for this report, about 65 percent are for drilled wells which tap both bedrock and the unconsolidated overburden. Dug wells constitute most of the remainder of the wells investigated, but some records were obtained for small-diameter driven or jetted wells. It should be recognized that the predominance of information reported for drilled wells over that reported for shallow dug or driven wells is influenced partly by the methods of field investigation. Records of deep drilled wells often constitute the principle source of preliminary information on the geology and ground-water conditions of an area, and well drillers are therefore contacted at an early point in any new investigational program. In the area covered by this report, however, the relative percentages of the several types of wells are influenced primarily by geologic conditions, and by the scope and types of industrial activity.

Dug wells.—Dug wells found chiefly in rural areas, furnish mainly domestic or farm supplies. Most of the dug wells range from 2 to 4 feet in diameter and from 10 to 20 feet in depth. Because of the large infiltration area available, the dug wells are able to extract small supplies from materials of low permeability. This factor, coupled with the large reservoir facilities offered, makes the dug well an adequate source for many homes and farms. The dug well, however, is more susceptible to failure during protracted dry periods when ground-water levels decline below the shallow well bottom. In addition, this type of well generally has a casing constructed of dry-laid stone or brick with innumerable openings that permit the inflow of polluted surface and shallow soil water. Construction of a satisfactory dug well, therefore, requires careful sealing against pollution from surface sources as well as adequate depth to assure an unfailing water supply during anticipated drought periods.

Driven wells.—The driven wells in the county range from 1¼ to 2 inches in diameter and from 20 to 30 feet in depth and are usually equipped with a 3-foot long screen (drive point). These wells can be installed only in soft permeable materials and in most cases cannot be driven through bouldery clay, layers of hardpan, or other indurated materials. The driven well generally can be pushed to greater depths than the dug well, and thus to a certain extent it reduces the opportunity for inflow of polluted surface waters and for failure during dry periods. In addition, the installation cost of a driven well is relatively small. The largest daily pumpage from such a well in Albany County occurs at well A363. This well, which is 21 feet deep and 1¼ inches in diameter, yields over 14,000 gallons per day.

Drilled wells.—Most of the drilled wells in Albany County that are used for domestic or farm purposes are 6 inches in diameter; but those used for industrial or municipal supplies range up to 12 inches in diameter, and in some cases are even larger. Wells that draw water from rock are usually cased down to the rock with the rock hole below left open. If the casing is tightly seated in bedrock, polluted water percolating through the overburden cannot enter the well and the entire supply enters from openings in the rock. In contrast, drilled wells that tap unconsolidated materials are cased to the bottom of the well and ground water can enter the well only through the open end of the casing or screen at the bottom of the well. The advantages to be derived by selecting appropriate screens and methods of well develop-

ment are particularly evident in Albany County where fine water-bearing sands are so widespread. Without development these sands yield very little or no water, and in the past drillers have often passed through them in search of water in the rock below.

Springs.—Some ground water in Albany County is recovered from springs. They are all gravity springs of either the contact or the depression type. In the former the water issues through permeable material because an underlying horizon of impermeable or less permeable material prevents further downward percolation. In the depression type, the water flows out of permeable material where the water table intersects the ground surface. Springs are scattered throughout the county and generally are of fifth magnitude,[43] 10 to 100 gallons per minute, or lower. A zone of larger springs, however, is present along the face of the Helderberg cliffs, where soluble limestones are underlain by impervious shale beds. One of these, A 11Sp (table 2), which forms part of the public supply for the town of Voorheesville, has a reported maximum flow of 1,000 gallons per minute. This spring issues through the Rondout limestone at the contact with the underlying impervious Brayman shale. A 12Sp, also part of the Voorheesville supply, issues through a joint plane in the Esopus shale and is reported to yield a maximum of 250 gallons per minute. Both these springs are subject to marked seasonal fluctuation dependent directly upon the amount of rainfall.

Infiltration galleries.—Two infiltration galleries have been constructed in Albany County, one supplying water for Green Island, and the other serving the Bethlehem water district. Basically, an infiltration gallery is a long shallow horizontal well dug into the zone of saturation for the purpose of collecting ground water. The Green Island gallery is 117 feet long, 6.5 feet high, and 6 feet wide at the base. It is situated in a bed of sand and gravel and terminates in a large-diameter shallow dug well. From there the water flows to another dug well from which it is pumped to the filter plant. The gallery is located in the middle of Magills Island and is about 22 feet below the ground surface. It is 12 feet below the normal stage of the Hudson River and approximately 32 feet below river flood level. The large amount of water supplied by the gallery, 250,000 gallons per day, coupled with the relatively small catchment area of the island, indicates that considerable river recharge might be involved.

The gallery serving the Bethlehem Water District is of somewhat different construction. Located at New Salem, across the highway from well A 82, it consists of a 105-foot long concrete wall, packed with gravel and cobblestone, which retains the ground water that seeps from a hillside. The water then flows to a large collecting basin from which it is distributed to the water system. The water from this source serves as an auxiliary to the main supply obtained from wells A 82 and A 83.

UTILIZATION

Tabulation of 492 wells, borings, and springs in Albany County for which records are available shows that about 80 percent of those in use are being pumped for domestic or farm purposes (table 5). Of the remainder, 7 wells supply water for drinking purposes at schools; 15 wells are utilized by hotels, restaurants, or garages for drinking, washing, and related purposes; 2 wells are used for swimming pools; 16 wells and 2 springs are used for industrial purposes; and 25 wells and 2 springs are used as public supplies.

Domestic supplies.—In areas not served by a public system, domestic water supplies throughout the county are obtained almost exclusively from wells and springs. The domestic uses of water include drinking, cooking, washing, and sewage disposal, and these needs are normally met by dug or drilled wells of low yield. Water for cattle and other farm animals is also obtained by the same method, and in many cases where the number of stock to be cared for is small one well suffices for both the farm and the household. The average consumption from this type of well is generally less than 500 gallons per day.

Records were obtained for 7 wells at schools. Water is used at these institutions almost wholly for drinking and sanitary purposes and the total consumption, therefore, is small.

Commercial supplies.—Records are available for 15 hotels, roadside restaurants, and garages which use ground water for drinking, washing, and other similar purposes. Estimates of usage indicate that the average consumption is less than 1,000 gallons per day.

[43] Meinzer, O. E., Outline of ground-water hydrology, with definitions: op. cit., p. 53.

Table 2.—Records of selected springs in Albany County, New York.

Spring number	Location[a]	Owner	Altitude above sea level (feet)[b]	Topography	Geologic subdivision	Yield (gallons per minute)	Temperature (°F.)	Use[c]	Remarks
A 1Sp	10X, 9.2S, 2.7E	Arthur McGarr	575	Hillside	Pleistocene till	..	..	Dom	Spring is reported to be dependable; improved with tile; equipped with an electric pump.
A 2Sp	10X, 8.0S, 4.3E	L. H. Youmans	300	Swamp	Pleistocene gravel	15	..	Farm	Water causes scale on boilers. Spring reported always to furnish sufficient quantity of water to meet needs.
A 3Sp	10X, 17.3S, 8.5E	Jesse Stalker	300	Base of cliff	Rondout limestone	10	..	Farm	Large seasonal variation in temperature is reported.
A 4Sp	10X, 14.4S, 11.7E	Joseph Sahloff	160	Hillside	Pleistocene gravel	..	..	Dom	Water flows by gravity to several houses.
A 5Sp	10X, 5.8S, 7.7E	G. H. Ziehm	240	Lowland	Pleistocene sand	..	..	Farm	Spring not used at present.
A 6Sp	10X, 10.7S, 5.5E	H. E. Atwood	260	Hillside	Pleistocene till	25	..	Farm	Other similar springs at this location.[d]
A 7Sp	10X, 9.2S, 1.6E	John F. Caswell	520	Hillside	Schenectady formation	..	..	Farm	Spring not used at present.
A 8Sp	10X, 17.2S, 8.6E	C. F. Rowe	200	Base of cliff	Rondout limestone	..	..	Dom	([d])
A 9Sp	10X, 17.2S, 6.7E	Chester Boice	410	Hillside	Onondaga limestone	7	53	Dom	Spring equipped with an electric pump.
A 10Sp	11X, 8.5N, 6.0W	Hall Herbstrasser	1,100	Valley	Pleistocene gravel	16	44	Farm	Water reported to contain hydrogen sulfide.[e]
A 11Sp	10X, 7.8S, 0.8E	Village of Voorheesville	865	Base of cliff	Rondout limestone	1,000	46	PWS	Seasonal fluctuation reported large.
A 12Sp	10X, 8.4S, 0.7E	Village of Voorheesville	1,150	Base of cliff	Esopus shale	250	46	PWS	Seasonal fluctuation reported large.
A 13Sp	10X, 6.8S, 0.4E	Thomas Brennan	450	Hillside	Pleistocene till	40	..	Dom	
A 14Sp	10X, 9.1S, 1.2E	Bethlehem Water District	800	Base of cliff	Rondout limestone	..	47	PWS	Spring not used at present.
A 16Sp	11X, 3.3N, 11.7W	William Meyer	1,960	Hillside	Kiskatom formation	4	48	Farm	Spring improved with concrete collecting basin.
A 17Sp	11W, 1.2S, 5.7E	Perry Lobdell	1,290	Hillside	Kiskatom formation	3	..	Farm	Spring improved with concrete collecting basin.
A 18Sp	10X, 16.2S, 0.7E	Arthur Palmer	820	Hillside	Mount Marion formation	..	..	Farm	Spring improved with concrete collecting basin.

a. The location of A 1Sp is 9.2 miles south and 2.7 miles east of the intersection of lines 10 and X. For further explanation of location symbols see section "Methods of investigation."
b. Approximate altitude from topographic map.
c. Dom, domestic; PWS, public water supply.
d. Record taken in part from "Contributions to the hydrology of eastern United States," by M. L. Fuller, U. S. Geol. Survey Water-Supply paper 102, p. 199, 1904.
e. For chemical analysis see table 3.

Two wells, A 101 and A 384, are used to provide water for swimming pools and the consumption is about 3,000 gallons per day each. These wells, however, are used only seasonally.

Industrial supplies.—Most of the industrial activity in Albany County is concentrated in the urban areas and consequently any large demand for water for industrial purposes has been met by municipal supplies. Records of private wells or springs used exclusively for industrial purposes have been obtained in only 18 cases. Of these, only three supply more than 10,000 gallons per day. Well A 363, a driven well 21 feet deep, supplies 14,000 gallons per day, the water being used for cooling purposes connected with apple storage. Well A 57, at Voorheesville, supplies 100,000 gallons per day, which is used in the manufacture of cider. The largest consumer is the Alleghany Ludlum Steel Corp., which obtains about 150,000 gallons per day from well A 241 for cooling purposes. The Behr-Manning Corp., one of the largest consumers in the area, uses an average of 400,000 gallons per day, but this is obtained from the Latham Water District, a public supply which obtains its water from wells.

Public supplies.—Although this report deals with ground water, it may be well to point out that by far the largest developed water supply in the county utilizes surface water. This supply is for the city of Albany. It is obtained from a watershed about 20 miles south of Albany, and provides for an average daily consumption of about 23 million gallons. Of the remaining 16 public supplies in Albany County, 9 utilize ground water. The Bethlehem Water District No. 1 obtains its supply from two 12-inch drilled wells and several auxiliary springs. The wells, A 82 and A 83 (table 5), are 94 and 87 feet deep, respectively, and are of "gravel-wall" construction. They tap a bed of coarse gravel lying about 70 feet below the ground surface. A test at well A 82 indicated a 7-inch drawdown after 46 hours of pumping at 540 gallons per minute. A similar test at well A 83 showed a drawdown of 1.2 feet after 19 hours of pumping at 500 gallons per minute. Recovery was immediate. The auxiliary supply consists of two springs and an infiltration gallery at New Salem, across the highway from wells A 82 and A 83. Another spring, A 19Sp, issuing from the Helderberg cliff, was formerly part of the system but is no longer in use. The Bethlehem Water District serves the communities of Delmar, Slingerlands, Elsmere, New Salem, and New Scotland and supplies an average of about 300,000 gallons per day. The water is chlorinated, and an anaylsis is given in table 3.

The community of McKownville is served by two small privately owned systems, one supplying surface water, and the other ground water. The ground-water system consists of more than 20 driven wells (A 199), which obtain water from a bed of sand about 15 feet below the surface. The wells are pumped by three interconnected pumps and the water is piped to several pressure tanks, whence it is distributed by gravity. The system supplies an average of 10,000 gallons per day. The water is not treated. Continued expansion of the community has made the present supplies wholly inadequate, and an investigation is now under way for establishing a larger community supply.

The Green Island public supply consists of an infiltration gallery and two dug wells. Water is first pumped to a filtration plant and from there it is pumped to a half-million-gallon distributing reservoir. The average consumption is about a quarter of a million gallons per day. The Green Island system is interconnected with the Watervliet supply so that the latter acts as a stand-by; in emergencies, water can also be pumped from the Hudson River.

The Hurstville supply consists of two privately owned wells, A 99 and A 100, which supply a group of houses located near the Albany Municipal Golf Course. These wells, both 6 inches in diameter, are 239 and 246 feet deep respectively and tap a bed of gravel. A test at well A 99 showed a 4-foot drawdown after 1 hour of pumping at 12 gallons per minute. Neither well is finished with a screen. Water is pumped to a 5,000-gallon pressure tank whence it is distributed at the rate of about 4,500 gallons per day.

The largest ground-water supply in Albany County is operated by the Latham Water District, which serves a large area in the northeast portion of the county. The system consists of 10 drilled wells, A 265—A 274, inclusive, from which water is pumped to one of several pressure tanks and subsequently distributed by gravity. The wells are, on the average, about 150 feet deep and 12 inches in diameter, and they obtain their water from various lenses of glacial sand and gravel scattered through the area. All the wells are finished with screens and several are gravel-packed. The quality of the water from each well is somewhat different and

therefore the treatment applied is different. In general, the water pumped from most of the wells is either chlorinated or aerated, and one well, A 271, has a complete softening plant. Pumpage from two of the wells, A 267 and A 273, averages over half a million gallons per day each. Total pumpage for the district exceeds two million gallons per day. As the water is withdrawn from limited aquifers a gradual lowering of the water table has occurred in the immediate area. When installed in 1930, well A 265 flowed at the land surface, but by the end of 1942 the static water level had declined to 29 feet below the surface. Similar conditions exist at well A 267. It flowed when installed in 1932 but by the end of 1942 the static water level had declined to 14 feet below land surface. The decline of water levels in the water-bearing beds around these wells has caused a lowering of water levels in several nearby privately-owned wells. The population served by the Latham district is continually increasing and a search for additional sources of water is being made.

The Southern Boulevard Heights development southwest of Kenwood is served by a small privately owned supply, which furnishes about 10,000 gallons per day. The system consists of a 223-foot, 6-inch drilled well, A 197, which obtains water from a gravel formation. The water is pumped to a pressure tank for eventual distribution; it is not treated. An analysis is given in table 3.

Another small privately owned supply serves the Tawasentha Heights development, located between Slingerlands and Albany. Water is obtained from two drilled wells, A 96 and A 97, 200 and 198 feet deep, respectively, which tap a bed of sand and deliver over 7,000 gallons per day. The water is not treated. An analysis is given in table 3.

The Voorheesville public supply is obtained from well A 58, which taps outwash sand and gravel; and an auxiliary spring, A 11Sp, located at the Rondout-Brayman contact plane in the Helderberg cliff. Normally the well is pumped continuously, and excess water is forced up to a 45,000-gallon buried reservoir located at the foot of the Helderbergs. This reservoir is kept full by inflow from spring A 11Sp. When consumption exceeds the output of well A 58, the direction of flow from the reservoir is reversed and the spring water runs down to augment the town supply. Connected into this system, but used only during fire-fighting emergencies, is an additional 1,000,000-gallon open reservoir which is fed by another spring, A 12Sp. The average daily consumption is about 140,000 gallons, which normally is supplied from well A 58. The water from all sources is chlorinated and, in addition, the open reservoir is treated with copper sulfate.

The supply for the U. S. Army Supply Depot at Guilderland Center is obtained from a shallow well screened in a layer of gravel. The average daily consumption is about 70,000 gallons per day. The water is not treated.

QUALITY

The general chemical characteristics of the ground water of Albany County is shown by the analyses in table 3. Analyses are given for 31 samples collected by the U. S. Geological Survey and analyzed in the laboratories of the New York State Health Department at Albany or of the U. S. Geological Survey at Washington, D. C. The relative location of the wells from which samples were taken is shown in figure 6.

Mineral constituents

Dissolved solids.—The dissolved solids are the residue left upon evaporation of a water sample. This residue is made up chiefly of the minerals shown in table 3, but a small quantity of organic material and a little water of crystallization are sometimes included. Water with less than 500 parts per million (one grain per U. S. gal. equals 17.118 p. p. m.) of dissolved solids is generally satisfactory for domestic use, except for the difficulties resulting from excessive hardness or iron content. Water with more than 1,000 parts per million is likely to contain enough of certain constituents to produce a noticeable taste or to make the water unsuitable in other respects. All the analyses of ground water in Albany County show less than 1,000 parts per million of dissolved solids but five show more than 500 parts per million. Only two show less than 100 parts per million (table 3). Water obtained from unconsolidated deposits is generally lower in mineral content than that obtained from the consolidated deposits. Of the latter, the shales underlying the eastern plains area generally yield

Table 3.—Chemical analyses of water from selected wells and springs in Albany County, New York. (Analyses by New York State Department of Health unless indicated otherwise. Dissolved constituents given in parts per million).

Well or spring number	Depth (feet)	Geologic subdivision [a]	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) + potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hardness (as $CaCO_3$) Total	Carbonate	Noncarbonate	pH
A 10	236	Snake Hill fm.	4/11/47	402	..	0.1	0.01	..	..	..	240	113	2.8	..	..	200	197	3	7.5
A 30	190	Pleistocene gravel	3/26/46	233	..	.5	.1	..	..	..	231	20	5.2	..	..	124	124	0	7.9
A 36	70	Schenectady fm.	4/ 2/47	858	..	.45	.075	..	..	..	514	302	3.6	..	..	240	240	0	7.4
A 57	70	Pleistocene gravel	3/25/46	371	..	.03	.015	..	..	..	207	81	15	..	..	260	170	90	7.5
A 83[b]	91	Pleistocene gravel	9/ 5/47	247	6.4	.2	.0	60	12	5.6	164	59	5.0	0.1	10	199	134	65	7.3
A 84	80	New Scotland ls.	7/30/47	217	..	1.3	.0	..	..	..	150	17	9.2	..	..	128	123	5	7.5
A 106	135	Esopus shale	4/ 2/47	388	..	.2	.0	..	..	..	350	11	29	..	..	4	4	0	9.1
A 107	96	Coeymans ls.	7/30/47	342	..	.05	.0	..	..	..	330	29	15	..	..	280	271	9	7.2
A 113	152	Snake Hill fm.	4/ 2/47	243	..	.1	.0	..	..	..	199	0	30	..	..	6	6	0	8.5
A 121	129	Onondaga ls.	5/16/46	534	..	.03	1.0	..	..	..	382	30	25	..	..	360	313	47	7.0
A 131	45	Snake Hill fm.	5/ 8/47	957	..	.2	.0	..	..	..	148	181	46	..	..	440	121	319	7.0
A 152	240	Normanskill shale	3/26/46	243	..	.1	.1	..	..	..	226	.7	23	..	..	4	4	0	9.3
A 174	273	Normanskill shale	5/16/46	575	..	1.0	.02	..	..	..	353	170	16	..	..	360	289	71	7.7
A 183	10	Pleistocene sand	3/26/46	188	..	.03	.0	..	..	..	61	53	11	..	..	90	50	40	6.5
A 266	303	Pleistocene gravel	4/19/46	293	..	.2	.05	..	..	..	124	109	5.6	..	..	208	102	106	7.9
A 273[b]	161	Pleistocene gravel	9/ 4/47	294	17	.28	.0	53	15	41	312	2.1	18	.2	.0	194	194	0	7.5
A 348	100	Coeymans ls.	7/30/47	484	..	.05	.0	..	..	..	322	55	31	..	..	350	264	86	7.4
A 368	60	New Scotland ls.	4/ 3/47	256	..	.25	.0	..	..	..	187	30	2.6	..	..	168	153	15	7.1
A 369	38	Schoharie grit	4/ 3/47	84	..	.15	.0	..	..	..	24	21	2.6	..	..	42	20	22	6.4
A 380	175	Mount Marion formation	4/ 8/47	148	..	.15	.01	..	..	..	132	17	3.0	..	..	96	96	0	7.6
A 396	120	Kiskatom fm.	4/30/47	184	..	.2	.1	..	..	..	194	14	.6	..	..	108	108	0	7.8
A 400	124	Kiskatom fm.	4/30/47	39	..	.22	.0	..	..	..	22	9.4	.2	..	..	30	18	12	6.8
A 410	113	Mount Marion formation	4/29/47	143	..	.25	.03	..	..	..	123	11	9.4	..	..	136	101	35	7.1
A 421	79	Mount Marion formation	4/10/47	282	..	.1	.02	..	..	..	235	20	15	..	..	280	193	87	7.7
A 429	85	Onondaga ls.	4/29/47	299	..	.2	.075	..	..	..	259	48	2.4	..	..	200	200	0	7.5
A 434	110	Bakoven shale	4/10/47	215	..	.2	.03	..	..	..	178	29	.8	..	..	84	84	0	8.0
A 444	552	Bakoven shale	4/29/47	188	..	.04	.0	..	..	..	176	26	1.0	..	..	152	144	8	7.5
A 445[b]	43	Onondaga ls.	9/10/47	403	8.8	.22	.0	94	17	15	321	44	18	.2	3.6	304	264	40	7.4
A 448	76	Onondaga ls.	7/31/47	254	..	.18	.0	..	..	..	267	22	.2	..	..	200	200	0	7.4
A 472	300	Schenectady fm.	4/11/47	768	..	.1	.01	..	..	..	466	33	180	..	..	52	52	0	8.7
A 10Sp	..	Pleistocene gravel	5/29/47	228	..	.03	.05	..	..	..	189	19	1.2	..	..	140	140	0	7.8

a. fm., formation; ls., limestone.
b. Analysis by U. S. Geological Survey, Quality of Water Branch.

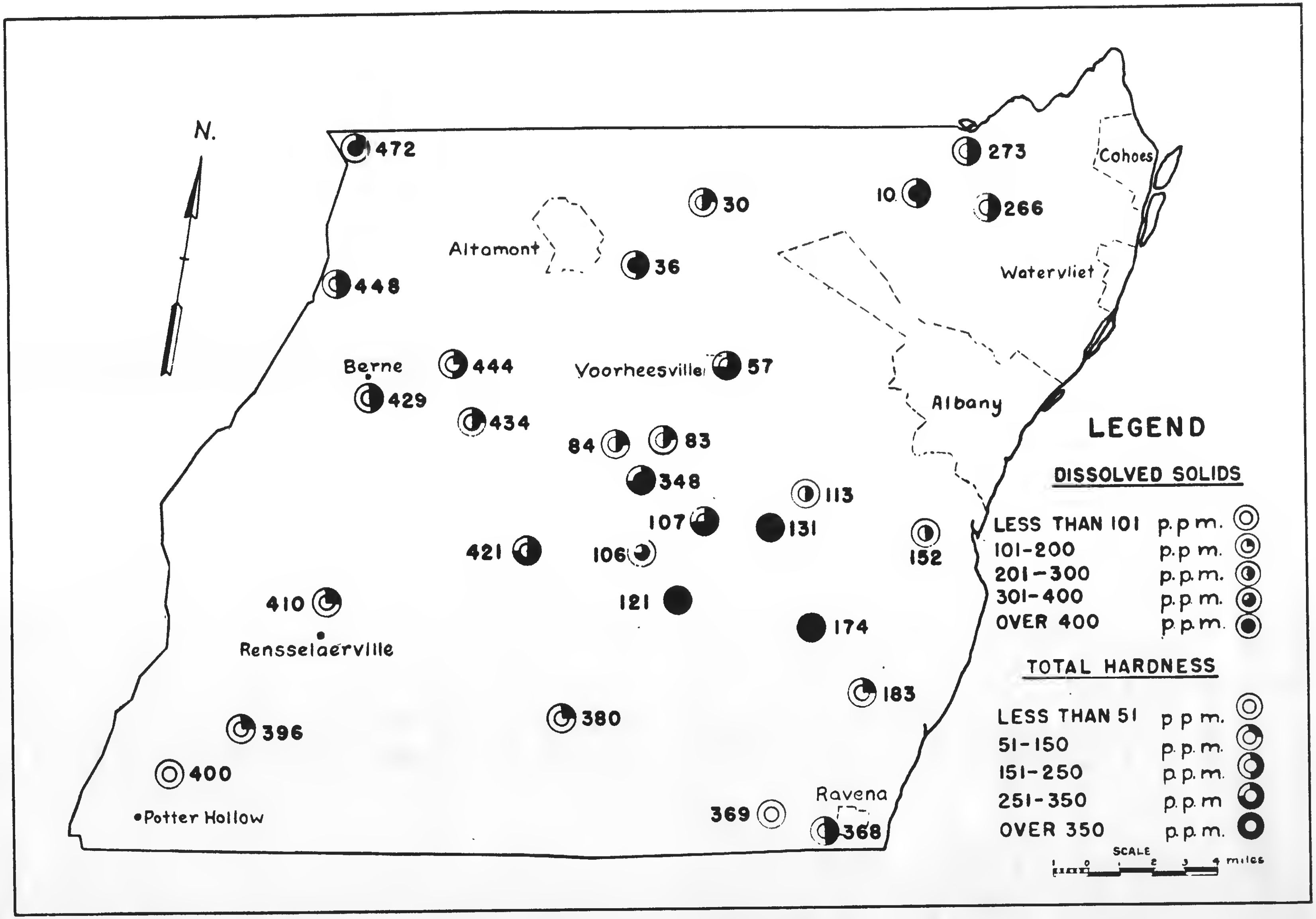

Figure 6.—Areal distribution of dissolved solids and total hardness in well waters in Albany County, New York.

water with the highest dissolved mineral content and the Hamilton group, occupying the highlands to the west, yields water with the lowest dissolved mineral content.

Iron (Fe).—Iron is dissolved from many rock materials. If a water contains much more than 0.3 part per million of iron the excess may separate out when exposed to the air and settle as a reddish sediment. Iron in the water sometimes stains cooking utensils and bathroom fixtures and it is very troublesome to industries such as laundering, tanning, and paper manufacturing. Iron is found in noticeable amounts in many of the ground waters of Albany County but only four of the samples analyzed show over 0.3 part per million of iron. Wells in unconsolidated deposits generally yield water having a higher iron content than does the water coming from consolidated deposits. The average iron content of well samples listed in table 3 is 0.23 part per million.

Manganese (Mn).—When present in quantities greatly exceeding 0.05 part per million manganese causes gray to black discolorations on many of the materials it contacts. It also causes clogging deposits in piping and is particularly troublesome in laundry and textile plants. Seven of the analyses showed over 0.05 part per million of manganese and one of these, A 121, had 1.0 part per million. The mean manganese content of the analysed samples shown in table 3 (excluding A 121) is 0.02 part per million.

Chloride (Cl).—Chloride is dissolved in small quantities from many rock materials and is one of the principal constituents in sea water. Sewage also may contain appreciable quantities of chloride, and a chloride content higher than normal for the region may be considered an indication of pollution. In areas such as Albany County this is particularly true in the case of shallow wells because the chloride content normally increases with the depth of the well. The U. S. Public Health Service recommends 250 parts per million as a limit for chloride in potable water. No figures exceeding this limit have been reported in Albany County and only two wells yield water that has more than 100 parts per million of chloride. The average chloride content for the wells and springs shown in table 3 is 17 parts per million. The average well depth is 142 feet.

Sulfate (SO_4).—Sulfate is dissolved in large quantities from gypsum and is formed from the oxidation of iron sulfides, principally pyrite. Sulfate in small amounts has little effect on the general use of a water but magnesium sulfate and sodium sulfate may be present in sufficient quantity to give a bitter taste. Sulfate in a hard water may increase the cost of softening and will form a hard adhering scale in a steam boiler. The U. S. Public Health Service recommends 250 parts per million as the limit for sulfate in a potable water. Only one analysis from Albany County exceeded this figure and the average sulfate content for 30 wells and one spring shown in table 3 is 51 parts per million.

Hardness.—Hardness of a water is most commonly recognized by the amount of soap required with the water to form a lather in washing. In addition to increasing the consumption of soap, calcium and magnesium, the constituents that cause hardness, are also the active agents in the formation of the greater part of all scale in steam boilers and in vessels in which water is heated or evaporated. Table 3 shows the total hardness as well as the carbonate and noncarbonate hardness of waters analyzed. Carbonate hardness, caused by the presence of calcium and magnesium bicarbonates (temporary hardness), can largely be removed by boiling the water. The noncarbonate hardness (permanent hardness), is due to the presence of calcium and magnesium chlorides or sulfates, which cannot be removed by boiling. The noncarbonate hardness generally forms a harder scale, but there is no difference between the two as far as consumption of soap is concerned. Water with a hardness of less than 50 parts per million is generally rated as soft and softening treatment is rarely justified. Hardness between 50 and 150 parts per million does not seriously interfere with the use of water for most purposes but it does increase the consumption of soap. Accordingly, softening may be profitable for laundries or other industries that use large quantities of soap. Treatment for the prevention of scale is necessary for the successful operation of steam boilers using water with a hardness approaching 150 parts per million. Hardness in excess of 150 parts per million is noticeable to everyone, and where the hardness is 200 or 300 parts per million it is common practice to soften water for household use or to install cisterns to collect rain water. Where municipal water supplies are softened an attempt is generally made to reduce the hardness to about 60 parts per million. The additional improvement from further softening an entire public supply is not deemed worth the added cost.

The analyses for Albany County show a wide range in total hardness (fig. 6), and 17 waters analyzed had a hardness of more than 150 parts per million. Five of these show more than 300 parts per million. The average total hardness for all the wells and springs analyzed is 175 parts per million. In general, the consolidated deposits yield water that is harder than water from the unconsolidated deposits, but within each group there is a wide variation according to locale and type of sediment involved.

Hydrogen-ion concentration (pH).—The hydrogen-ion concentration of a water is expressed by the unit pH, and its importance lies in its indication of the corrosiveness of the water. The pH of a water is the negative exponent of the concentration of hydrogen-ions in grams per liter. Thus a low pH value means a high concentration of hydrogen ions, or a high acidic value, and a high pH value indicates a low concentration of hydrogen ions, or a low acidic value. A neutral water has a pH of 7.0. The waters analyzed from Albany County show a range in pH from 6.4 to 9.3 and an average value of 7.6. The pH value should be determined immediately after the sample is collected because changes in the alkalinity of the water occur upon contact with the air. The analyses in table 3 were not made until several days after the samples were collected, and pH values reported may not be representative of the original waters as they came from the wells and springs.

Temperature

The temperature of the water used for cooling or air-conditioning purposes is of more importance than its chemical characteristics. Water with consistently low temperature is preferred and in this respect ground water is vastly superior to surface water. The temperature of stream waters directly reflects the local atmospheric conditions and may range from 32°F. to more than 80°F. throughout the course of a year. The temperature of ground water, however, at depths of as much as 100 feet, generally remains within a few degrees of the mean annual air temperature of the region, regardless of the season. The ground-water temperature increases with depth at the rate of about 1° for each 100 feet. The mean annual air temperature at Albany is 48°F., whereas temperatures listed in table 5 for 45 wells indicate an average of about 50°. Spring temperatures, as shown in table 2, are somewhat lower, averaging 47°. The temperature of water obtained from shallow wells may be expected to vary more throughout the year than that of water obtained from deeper wells.

Relation to rock type

Shale.—The shales in Albany County include the Normanskill shale and the shales of the Snake Hill and Schenectady formations. These beds generally yield waters that are high in mineral content—often over 500 parts per million—but the amount of the different constituents present varies greatly. The chloride content ranges from less than 3 parts per million to 180 parts per million; and the sulfates from 0 to over 300 parts per million. The total hardness ranges from 4 to 440 parts per million. These differences are largely independent of the depth of the wells and probably are due to the presence of insoluble chert and grits and soluble limestone lenses, which are interbedded with the main shale beds. Many wells in the shales have been reported by their owners to have a high sulphur content. This is due to the presence of hydrogen sulfide, which is believed to be formed by reduction of the sulfates found in the shale.

Limestone.—The limestones of the county include the Rondout, Manlius, Coeymans, Kalkberg, New Scotland, Becraft, and Onondaga limestones. The dissolved mineral content of waters from these limestones is generally less than 500 parts per million and appears to be proportional to the depth of the well. The chloride and sulfate content is less than average for the region. Water from most of the limestones is consistently hard, however, averaging about 225 parts per million in total hardness. Water from the Kalkberg and New Scotland limestones generally shows a lower hardness, because of the presence of the shaly beds in these formations.

Grits.—The formations identified as grits include the Esopus shale and the Schoharie grit. Only one analysis is available for each formation, but these indicate that the grits, particularly the Schoharie, yield water with a low mineral content. Both samples show figures below the county average for iron, manganese, and sulfate. The waters obtained from these formations appear to be softer than waters in other aquifers in the county.

Hamilton group.—The Bakoven shale, the Mount Marion, Ashokan, and Kiskatom formations are included in the Hamilton group. The dissolved mineral content of waters from these formations is low, less than 300 parts per million in the Bakoven shale, and generally less than 200 parts per million in the younger formations. The iron, manganese, chloride, and sulfate content all run well below average for the county, and the hardness figure of the waters is very low, averaging 100 parts per million for the nine samples analyzed.

Unconsolidated deposits.—According to seven analyses in table 3, waters from the unconsolidated glacial deposits in Albany County show a wide range of chemical composition. The dissolved mineral content averages about 265 parts per million, which is substantially lower than that for waters from the consolidated rocks in the county. The iron content ranges from 0.03 to 0.5 part per million; the manganese content from less than 0.01 to 0.1 part per million; the chloride content from 1.2 to 18 parts per million; and the sulfate content from less than 3 to more than 100 parts per million. The range in total hardness is from 90 to 260 parts per million. This wide diversity of chemical characteristics is determined by the character of the source from which the glacial deposits were derived. This in many cases is the bedrock of the immediate area. The bedrock in Albany County as a whole, however, is highly diversified and even the shales which underlie most of the eastern section vary greatly in their chemical nature. It is to be expected, therefore, that waters obtained from the glacial deposits derived from this collection of dissimilar rocks would also show widely diversified chemical characteristics, depending on the character and solubility of the rock materials with which the water was in contact.

SUMMARY OF GROUND-WATER CONDITIONS

The primary source of ground water in Albany County is the rain and snow which falls on the immediate area. There is no indication of any extensive subterranean flow of ground water into the county from adjacent areas.

Ground water generally occurs throughout the county under water-table conditions. Flowing wells are not uncommon but are believed to be caused by local conditions. No extensive artesian horizons are known to exist.

Almost without exception the consolidated deposits in the area are dense, compact, impervious rocks which yield water only from joints, bedding planes, or solution channels. Openings of this nature are difficult to anticipate and generally tend to pinch out with depth. Yields from the rock wells, therefore, show a considerable range, but on the whole they are rather poor. The most extensively used rock aquifers are the Ordovician shales, the Onondaga limestone, and the formations of the Hamilton group. The shales generally yield small amounts of water which are almost always of poor quality. Yields from the Onondaga and Hamilton, though somewhat greater, still rarely exceed 20 gallons per minute. Water from the Onondaga is usually quite hard but that from the Hamilton is generally of excellent quality.

The unconsolidated glacial deposits constitute the chief water-bearing bed of the area. They vary in character from unassorted till to well-sorted outwash deposits, and consequently there is considerable range in yields. The till yields only small quantities of water to dug wells of large diameter and is tapped only for domestic purposes. The clays, which constitute the finer outwash deposits, are practically impervious. The sands yield water readily to dug and driven wells and the latter are widely used to supply water for domestic and farm purposes. The coarser glacial deposits are the most prolific aquifers in the county. Undeveloped wells in this source show an average yield of 30 gallons per minute, developed wells average 300 gallons per minute, and a maximum of 700 gallons per minute has been reported. The quality of water obtained from the glacial deposits shows a considerable range, but on the average the water has a lower mineral content then does that obtained from the rock aquifers. The unconsolidated deposits constitute the only major source from which future demands for large quantities of water can be satisfied.

Ground water in Albany County is recovered chiefly by means of wells. Some small springs of the gravity type are utilized, primarily for domestic and farm purposes. Several larger ones, however, issue from the base of the Helderberg escarpment and have long been used as public supplies or to augment public supplies from another source. Wells of the dug

and driven variety are utilized mostly for domestic and farm purposes, whereas the drilled wells are used for the same purposes and also for industrial and public supplies. The individual industrial demand for ground water, however, is slight. Most industry is concentrated in urban areas, and consequently any large demand for water for industrial purposes has been met by the municipal supplies. The total pumpage for industrial purposes from privately owned wells and springs throughout the county is about 400,000 gallons per day. Nine of the seventeen public supplies in Albany County are obtained from ground water, and the average daily consumption at these ground-water plants is over three million gallons per day. The largest of the public supplies is the Latham Water District, which consists of 10 wells pumping from sand and gravel strata. The total pumpage exceeds two million gallons per day, and this large withdrawal has resulted in a gradual lowering of the water table throughout the immediate area. This, coupled with a concurrent growing demand for water, has created the only situation in Albany County where the water problem may be classified as critical. In all other places the demand has been well met by existing ground and surface supplies.

REFERENCES

1. Berkey, C. P., *Geology of the New York City aqueduct*: New York State Mus. Bull. 146, 1911.
2. Chadwick, G. H., *Geology of the Catskill and Kaaterskill quadrangles, pt. 2*: New York State Mus. Bull. 336, 1944.
3. Cleland, H. F., *Post-Tertiary erosion and weathering*: Am. Jour. Sci. 19, 1930.
4. Collins, W. D., and Howard, C. S., *Chemical characters of waters of Florida*: U. S. Geol. Survey Water-Supply Paper 596 G, 1927.
5. Collins, W. D., Lamar, W. L., and Lohr, E. W., *The industrial utility of public water supplies in the United States*: U. S. Geol.Survey Water-Supply Paper 658, 1934.
6. Cook, J. H., *Glacial geology of the Capital district*: New York State Mus. Bull. 285, 1930.
7. Cook, J. H., *Glacial geology of the Berne quadrangle*: New York State Mus. Bull. 303, 1935.
8. Dale, T. N., *The slate belt of eastern New York and western Vermont*: U. S. Geol. Survey 19th Ann. Rept., pt. 3, 1899.
9. Goldring, Winifred, *Handbook of paleontology for beginners and amateurs, pt. 2*: New York State Mus. Handbook 10, 1931.
10. Goldring, Winifred, *Guide to the geology of John Boyd Thacher park and vicinity (Indian Ladder Region)*: New York State Mus. Handbook 14, 1933.
11. Goldring, Winifred, *Geology of the Berne quadrangle*: New York State Mus. Bull. 303, 1935.
12. Goldring, Winifred, *Geology of the Coxsackie quadrangle*: New York State Mus. Bull. 332, 1943.
13. Meinzer, O. E., *The occurrence of ground water in the United States*: U. S. Geol. Survey Water-Supply Paper 489, 1923.
14. Meinzer, O. E., *Outline of ground-water hydrology with definitions*: U. S. Geol. Survey Water-Supply Paper 494, 1923.
15. Parker, J. M., *Regional systematic jointing in slightly deformed sedimentary rocks*: Geol. Soc. America Bull. 53, March 1942.
16. Ruedemann, Rudolf, *Geology of the Capital district*: New York State Mus. Bull. 285, 1930.
17. Ruedemann, Rudolf, *Notes on Ordovician plankton and radiolarian chert of New York*: New York State Mus. Bull. 327, 1942.
18. Ruedemann, Rudolf, *Geology of the Catskill and Kaaterskill quadrangles, pt. 1*: New York State Mus. Bull. 331, 1942.
19. Simpson, E. S., *Buried preglacial channels in the Albany-Schenectady area of New York State*: unpublished manuscript, U. S. Geol. Survey, Ground-Water Branch.
20. Ulrich, E. O., and Schuchert, Charles, *Paleozoic seas and barriers in Eastern North America*: New York State Mus. Bull. 52, 1902.
21. Woodworth, J. B., *Ancient water levels of the Champlain and Hudson valleys*: New York State Mus. Bull. 84, 1905.

Table 4.—Driller's logs of selected wells in Albany County, New York.

(Altitudes are approximate elevations above mean sea level, as taken from the topographic map)

A 4; 10X, 0.3S, 7.6E; dug well; altitude 320 feet.

	Thickness (feet)	Depth (feet)
Sand	1	1
Hardpan	4	5
Clay, blue	10	15
Quicksand	1	16
Clay, blue	8	24
Gravel	1	25

A 23; 10X, 2.7S, 10.1E; drilled by Van Nouhuys in 1923; altitude 295 feet.

	Thickness (feet)	Depth (feet)
Clay and quicksand	19	19
Hardpan	2	21
Gravel	4	25

A 39; 10X, 3.3S, 2.8E; dug well; altitude 380 feet.

	Thickness (feet)	Depth (feet)
Clay and stone	11	11
Gravel	4	15
Sand, coarse	18	33

A 48; 10X, 6.3S, 0.0E; drilled by Platz and Ogsbury in 1945; altitude 400 feet.

	Thickness (feet)	Depth (feet)
Hardpan and boulders	48	48
Clay	1	49
Gravel	4	53
Schenectady formation at	....	53

A 82; 10X, 9.0S, 1.9E; drilled by Harris-Harmon Co. in 1940; altitude 400 feet.

	Thickness (feet)	Depth (feet)
Brown clay with boulders	26	26
Brown silty sand	14	40
Clay and fine gravel	3	43
Large heavy boulders	5	48
Brown clay and gravel	11	59
Large stones and coarse gravel	11	70
Gravel (75-80 percent) with small amount of clay	24	94
Gravel with more clay	2	96
Clay	5	101

A 99; 10X, 6.6S, 9.1E; drilled by Hall & Co., Inc., in 1937; altitude 220 feet.

	Thickness (feet)	Depth (feet)
Clay	238	238
Fine gravel	1	239

A 132; 10X, 12.0S, 6.2E; drilled by L. Heimberg in 1945; altitude 250 feet.

	Thickness (feet)	Depth (feet)
Clay	10	10
Sand	15	25
Gravel	7	32

Table 4.—Driller's logs of selected wells in Albany County, New York. (Continued)

A 143; 10X, 8.7S, 8.5E; drilled by Hall & Co., Inc., in 1934; altitude 15 feet.

	Thickness (feet)	Depth (feet)
Sand and gravel	11	11
Sandy clay	14	25
Coarse sand with clay	10	35
Sand (water bearing)	5	40
Gravel	12	52
Clay	30	82
Hardpan	6	88
Clay	15	103
Normanskill shale at	....	103

A 147; 10X, 9.7S, 11.9E; drilled well; altitude 60 feet.

	Thickness (feet)	Depth (feet)
Gravel and clay	88	88
Slate (Normanskill shale)	50	138
Bluestone (Normanskill shale)	6	144

A 167; 10X, 12.7S, 10.9E; drilled by E. Osterhaut in 1931; altitude 180 feet.

	Thickness (feet)	Depth (feet)
Sand	3	3
Clay	132	135
Limestone (Normanskill shale)	2	137

A 190; 10X, 14.8S, 11.5E; drilled by Hall and Co., Inc., in 1938; altitude 140 feet.

	Thickness (feet)	Depth (feet)
Clay	70	70
Sand	10	80
Normanskill shale	25	105

A 191; 10X, 16.3S, 9.6E; drilled by Richardson Brothers in 1942; altitude 140 feet.

	Thickness (feet)	Depth (feet)
Clay	165	165
Quicksand	75	240
Gravel	3	243
Normanskill shale at	....	243

A 193; 10X, 10.3S, 11.3E; drilled by Hall and Co., Inc., in 1941; altitude 200 feet.

	Thickness (feet)	Depth (feet)
Clay	156	156
Black sand	16	172
Slate (Normanskill shale)	83	255

A 216; 10X, 6.5S, 8.1E; drilled by Battle Brothers in 1927; altitude 180 feet.

	Thickness (feet)	Depth (feet)
Yellow clay	6	6
Blue clay	121	127
Sand and gravel	5	132
Packed sand, boulders, and hardpan	40	172
Slaty rock	16	188

Table 4.—Driller's logs of selected wells in Albany County, New York. (Continued)

A 224; 10X, 6.8S, 12.5E; drilled in 1928; altitude 115 feet.

	Thickness (feet)	Depth (feet)
Blue clay	98.5	98.5
Fine sand	4.5	103
Coarse sand or gravel	8	111
Mixture fine sand	10	121
Quicksand	1	122
Bedrock	13	135

A 231; 10X, 7.9S, 12.7E; drilled by Hall & Co., Inc., in 1945; altitude 10 feet.

	Thickness (feet)	Depth (feet)
Brick, gravel, and till	5	5
Soft clay	20	25
Fine gravel with clay	10	35
Fine sand with clay	5	40
Fine gravel with clay	6	46
Fine sand	2	48
Fine gravel with clay	8	56
Rock (Normanskill shale)	16	72

A 256; 9Y, 14.8S, 0.6E; drilled by Hall and Co., Inc., in 1935; altitude 260 feet.

	Thickness (feet)	Depth (feet)
Cemented gravel and hardpan	18	18
Bluestone (Normanskill shale)	32	50
Sandstone (Normanskill shale)	33	83

A 263; 10X, 7.1S, 12.0E; drilled by Chauncey Hover in 1905; altitude 160 feet.

	Thickness (feet)	Depth (feet)
Yellow and blue clay	20	20
Black shale	980	1000

A 265; 10X, 8.7S, 10.7E; drilled by Layne-New York Co., Inc., in 1930; altitude 300 feet.

	Thickness (feet)	Depth (feet)
Sandy clay	10	10
Fine sand and blue clay	43	53
Hard packed sand	72	125
Layers of fine sand	45	170
Tough blue clay and coarse sand and gravel	51	221
Boulders	24	245
Hardpan	1	246

A 267; 10X, 0.1S, 10.7E; drilled by Layne-New York Co., Inc., in 1932; altitude 280 feet.

	Thickness (feet)	Depth (feet)
Top soil	10	10
Sand	65	75
Blue clay	75	150
Sand	15	165

Table 4.—Driller's logs of selected wells in Albany County, New York. (Continued)

A 268; 10X, 0.3S, 10.9E; drilled by Layne-New York Co., Inc., in 1932; altitude 285 feet.

	Thickness (feet)	Depth (feet)
Yellow clay	7	7
Blue clay	33	40
Dark gravel	10	50

A 269; 10X, 0.5S, 5.0E; drilled by Layne-New York Co., Inc., in 1934; altitude 340 feet.

	Thickness (feet)	Depth (feet)
Yellow sand	12	12
Blue clay	2	14
Yellow sandy clay	11	25
Gray sand	10	35
Brown clay	2	37
Gray fine sand	13	50
Gray coarse sand	23	73
Schenectady formation at	....	73

A 271; 10X, 1.6S, 11.1E; drilled by Layne-New York Co., Inc., in 1941; altitude 320 feet.

	Thickness (feet)	Depth (feet)
Brown sand	14	14
Shale and boulders	6	20
Fine brown and gray sand	10	30
Fine brown sand and some gravel	19	49
Sandy blue clay	10	59
Black gravel and sand	5	64
Black gravel, some clay, and sand	19	83
Black gravel, more sand	7	90
Black shale and boulders	25	115
Hard sand and shale	5	120
Black hard rock	3	123
Soft blue clay	4	127
Black hard rock (Snake Hill formation)	20	147

A 272; 10X, 3.3S, 9.6E; drilled by Layne-New York Co., Inc., in 1942; altitude 290 feet.

	Thickness (feet)	Depth (feet)
Top soil	1	1
Fine brown sand	9	10
Fine brown sand and streaks of hardpan	27	37
Blue clay	16	53
Fine sand and clay	46	99
Tough blue clay	6	105
Fine sand and clay	43	148
Blue clay	55	203
Sand, shale, clay, and boulders	15	218
Blue rock (Snake Hill formation)	11	229

A 273; 9X, 16.1S, 9.8E; drilled by Layne-New York Co., Inc., in 1942; altitude 210 feet.

	Thickness (feet)	Depth (feet)
Sandy clay	6	6
Fine sand	8	14
Blue clay	99	113
Coarse black sand, gravel, and clay	7	120

Table 4.—Driller's logs of selected wells in Albany County, New York. (Concluded)

A 273; (continued)

	Thickness (feet)	Depth (feet)
Gravel and boulders	2	122
Coarse black sand and heavy gravel	23	145
Coarse gravel	13	158
Boulders and gravel, hard streaks	15	173
Snake Hill formation	2	175

A 341; 10X, 6.8S, 11.6E; drilled in 1946; altitude 177 feet.

	Thickness (feet)	Depth (feet)
Top soil	1	1
Till	3	4
Silt and clay	65	69
Sand and gravel	0.5	69.5
Shale	2.5	72

A 352; 10X, 6.8S, 12.8E; drilled by Hall and Co., Inc., in 1947; altitude 50 feet.

	Thickness (feet)	Depth (feet)
Red clay	30	30
Blue clay	40	70
Gravel, sand, and hardpan	8	78
Shale	247	325

A 421; 10W, 13.0S, 11.6E; drilled by L. Heimberg in 1942; altitude 1,460 feet.

	Thickness (feet)	Depth (feet)
Dirt	5	5
Clay	11	16
Hardpan	4	20
Bluestone	59	79

A 423; 10W, 12.5S, 7.0E; dug well; altitude 1,200 feet.

	Thickness (feet)	Depth (feet)
Dirt	2	2
Yellow clay	4	6
Hardpan	8	14
Sand	2	16

A 474; 11W, 4.5S, 6.1E; drilled by W. Tallman in 1943; altitude 800 feet.

	Thickness (feet)	Depth (feet)
Hardpan	92	92
Quicksand	30	122
Gravel	15	137

Table 5.—RECORDS OF SELECTED WELLS IN ALBANY COUNTY, NEW YORK

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F)	Use[f]	Remarks
A 2	10X, 0.4S, 2.9E	E. Bachand	330	Drv	21	1¼	..	Pleistocene sand	12	Suction	..	..	Dom	
A 4	10X, 0.3S, 7.6E	H. R. Sautter	320	Dug	25	36	..	Pleistocene gravel	15	..	..	..	Dom	
A 7	10X, 1.0S, 6.8E	J. Dulski	320	Drv	14	1¾	..	Pleistocene sand	8	Suction	..	..	Farm	
A 8	10X, 0.9S, 7.7E	N. Campbell	310	Drv	30	1¼	..	Pleistocene sand	22	Suction	..	50	Dom	
A 9	10X, 0.7S, 8.6E	W. C. Maples	380	Drl	266	6	84	Snake Hill formation	..	None	0	..	Dom	Driller reports no yield.
A 10	10X, 0.7S, 8.6E	W. C. Maples	380	Drl	236	6	81	Snake Hill formation	..	..	..	53	Dom	([g])
A 11	10X, 1.0S, 8.8E	Dr. H. Richman	310	Dug	38	30	38	Pleistocene sand	10	..	..	..	Dom	
A 13	10X, 1.8S, 7.4E	G. Hulse	320	Drv	17	1¼	..	Pleistocene sand	4	Suction	..	54	Farm	
A 14	10X, 1.5S, 8.9E	P. N. Conaway	300	Drv	8	1¼	..	Pleistocene sand	10	Suction	..	..	Dom	
A 15	10X, 1.8S, 9.1E	L. Andrews	295	Drv	20	1¼	..	Pleistocene sand	10	Suction	..	..	Dom	
A 17	10X, 1.5S, 10.4E	Peter Ahl	310	Drv	24	1¼	..	Pleistocene sand	4	Suction	..	..	Farm	
A 18	10X, 2.7S, 8.2E	P. Leromain	300	Drv	12	1¼	..	Pleistocene sand	7	Suction	..	..	Dom	
A 19	10X, 2.3S, 9.6E	C. W. Erdman	295	Drv	45	1¼	..	Pleistocene sand	8	Suction	..	..	Farm	
A 20	10X, 1.0S, 10.0E	F. A. Smith	300	Drv	20	2	..	Pleistocene quicksand	6	Suction	..	..	Farm	
A 21	10X, 1.8S, 12.6E	W. Brewster	380	Drl	190	8	50	Snake Hill formation	..	..	9	..	Dom	
A 23	10X, 2.7S, 10.1E	E. Curran	295	Drv	25	2	..	Pleistocene gravel	8	Suction	..	..	Farm	([h])
A 24	10X, 2.5S, 11.3E	School District 21	310	Drl	80	6	80	Pleistocene gravel	..	..	..	..	Dom	
A 25	10X, 3.7S, 9.1E	Capitol Block Co.	250	Drv	20	1¼	..	Pleistocene sand	5	Suction	..	..	Ind	
A 26	10X, 3.2S, 10.3E	L. Krauss	295	Drv	25	1¼	..	Pleistocene sand	10	Suction	..	..	Dom	
A 27	10X, 4.2S, 11.3E	G. Collins	220	Drl	104	6	..	Pleistocene sand	15	..	8	..	Dom	Driller reports well flowed at a rate of 2 gallons per minute when drilled in 1933.
A 28	10X, 4.3S, 11.5E	G. Klopfer	220	Drl	99	6	..	Pleistocene sand	15	..	5	..	Farm	Water reported to contain hydrogen sulfide
A 30	10X, 1.8S, 2.4E	R. Sharp	290	Drl	190	6	..	Pleistocene gravel	100	Force	7	52	Dom	([g])
A 32	10X, 2.0S, 3.5E	C. F. Durfee	300	Drv	18	1½	..	Pleistocene sand	2	Suction	..	..	Ind	
A 33	10X, 2.9S, 2.0E	U. S. Army	320	Drl	25	8	..	Pleistocene gravel	10	Force	..	51	PWS	Well finished with a screen. Average yield is 70,000 gallons per day.
A 34	10X, 2.8S, 1.1E	M. Fick	320	Drl	136	6	58	Schenectady formation	20	Force	..	..	Dom	Water reported to contain hydrogen sulfide.
A 35	10X, 3.1S, 1.1E	C. R. Miltner	315	Dug	18	48	..	Pleistocene till	8	Suction	..	..	Dom	Well is dry during periods of low precipitation.
A 36	10X, 3.9S, 0.6E	J. B. Hawes	340	Drl	70	6	19	Schenectady formation	13	Jet	..	50	Dom	([g])

See footnotes at end of table.

Table 5.—Records of selected wells in Albany County, New York (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
A 37	10X, 3.4S, 1.8E	C. Frank	320	Dug	21	60	..	Pleistocene till	5	Suction	..	..	Dom	
A 38	10X, 3.4S, 2.1E	G. L. F. Petroleum Service	280	Drl	285	6	15	Schenectady formation	..	None	0	..	Dom	Driller reports no yield.
A 39	10X, 3.3S, 2.8E	E. C. Vandenburgh	380	Dug	33	96 to 48	..	Pleistocene gravel	5	Force	..	52	Farm	Water reported to contain hydrogen sulfide.[h]
A 40	10X, 3.3S, 3.5E	M. J. Crounse	300	Dug	20	60	..	Pleistocene clay and sand	5	Suction	..	54	Dom	
A 41	10X, 3.0S, 3.9E	R. Andrews	260	Dug	7	48	..	Pleistocene sand	9	Suction	..	..	Farm	Drawdown reported large.
A 46	10X, 4.8S, 3.5E	A. C. Harrington	330	Drl	55	6	18	Schenectady formation	4	..	1½	..	Dom	
A 48	10X, 6.3S, 0.0E	L. D. Bates	400	Drl	53	6	53	Pleistocene gravel	27	Jet	..	52	Farm	([h])
A 50	10X, 6.7S, 1.3E	P. G. D. Ten Eyck	385	Drl	78	6	78	Pleistocene gravel	45	Jet	..	50	Ind	
A 52	10X, 6.8S, 1.9E	J. Olsmit	375	Drl	108	6	..	Pleistocene deposits	50	Force	..	50	Farm	Well finished with a screen.
A 53	10X, 6.8S, 1.9E	J. Olsmit	375	Dug	26	60	..	Pleistocene deposits	1	Suction	..	50	Farm	
A 54	10X, 6.7S, 2.4E	T. Gillespie	370	Drl	60	6	..	Pleistocene gravel	45	Force	..	..	Dom	
A 55	10X, 6.8S, 2.9E	A. M. Hurst	360	Drl	55	6	..	Pleistocene gravel	18	..	6	..	Dom	
A 57	10X, 6.7S, 3.8E	Duffy-Mott Co.	330	Drl	70	6	..	Pleistocene gravel	20	Force	100	48	Ind	Drawdown reported 2 feet after pumping 100 gallons per minute for 12 hours. Average production is 100,000 gallons per day.[g]
A 58	10X, 6.6S, 4.0E	Village of Voorheesville	330	Drl	35	6	..	Pleistocene gravel	12	Force	97	50	PWS	Drawdown reported 8 feet after pumping 97 gallons per minute for one month. Average yield is 140,000 gallons per day. Well finished with 6 feet of 6-inch screen.
A 59	10X, 5.7S, 5.9E	H. Albright	125	Dug	17	36	..	Pleistocene clay	10	Force	..	..	Farm	
A 60	10X, 5.2S, 6.4E	C. W. Albright	230	Drv	34	1½	..	Pleistocene sand	25	Suction	..	..	Dom	Well serves four families.
A 62	10X, 4.5S, 6.9E	F. Johnston	220	Drv	27	1¼	..	Pleistocene sand	17	Suction	..	..	Dom	
A 63	10X, 4.0S, 6.3E	G. N. Herrle	250	Drv	21	1¼	..	Pleistocene sand	14	Suction	..	..	Dom	
A 64	10X, 4.1S, 6.8E	D. Willey	285	Drv	28	1¼	..	Pleistocene sand	16	Suction	..	..	Dom	
A 67	10X, 4.0S, 7.3E	William Gipp	290	Drv	25	1¼	..	Pleistocene sand	12	Suction	..	..	Farm	
A 68	10X, 3.2S, 7.8E	Peter Holmes	280	Drv	11	1¼	..	Pleistocene sand	3	Suction	..	..	Farm	
A 72	10X, 5.1S, 8.0E	A. Sandow	200	Drv	20	1¼	..	Pleistocene sand	3	Suction	..	..	Dom	Water reported to contain iron.
A 73	10X, 6.1S, 7.9E	J. B. Stouder	260	Drl	30	10	..	Pleistocene sand	12	Centrifugal	6	..	Dom	Well finished with a screen.
A 74	10X, 5.6S, 5.6E	William Radliff	260	Drl	147	6	140	Schenectady formation	..	Suction	..	54	Farm	Well flows at a rate of 8½ gallons per minute.

See footnotes at end of table.

Table 5.—Records of selected wells in Albany County, New York (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
A 75	10X, 7.1S, 4.8E	J. J. Tice	300	Dug	18	36	..	Pleistocene till	2	Suction	..	..	Dom	
A 77	10X, 7.9S, 5.2E	W. M. Taylor	250	Dug	12	72	..	Pleistocene gravel	3	None	..	..	Farm	Gravity feed is used. Some quicksand reported.
A 81	10X, 9.0S, 1.6E	E. Crabill	400	Dug	18	36	..	Pleistocene till	13	Suction	..	..	Dom	Well serves six families.
A 82	10X, 9.0S, 1.9E	Bethlehem Water District	400	Drl	94	24 to 12	..	Pleistocene gravel	50	Force	540	..	PWS	Drawdown reported 7 inches after pumping 540 gallons per minute for 46 hours. Well finished with 27 feet of 12-inch screen.[h]
A 83	10X, 8.9S, 2.0E	Bethlehem Water District	400	Drl	87	24 to 12	..	Pleistocene gravel	37	Force	500	47	PWS	Drawdown reported 1.2 feet after pumping 500 gallons per minute for 19 hours. Well finished with 27 feet of 12-inch screen.[g]
A 84	10X, 9.2S, 1.2E	Osterhout Bros.	750	Drl	80	6	15	New Scotland limestone	40	Force	..	50	Com	([g])
A 87	10X, 9.7S, 1.5E	M. Caswell	750	Drl	222	6	24	New Scotland limestone	86	Force	4	..	Com	
A 89	10X, 9.8S, 2.2E	W. Hurtz	450	Dug	12	72	..	Pleistocene till	6	Centrifugal	..	..	Farm	
A 90	10X, 8.9S, 3.9E	H. G. Breeze	460	Drl	80	10	62	Schenectady formation	51	Force	15	..	Dom	
A 91	10X, 9.1S, 3.9E	J. R. Greeley	480	Drl	120	8	95	Schenectady formation	55	Force	2½	53	Dom	
A 92	10X, 9.2S. 3.8E	Dr. Erickson	500	Drl	164	10	164	Pleistocene gravel	28	Force	4½	..	Dom	Drawdown reported 44 feet after pumping 4½ gallons per minute for 260 hours.
A 95	10X, 7.9S, 7.6E	H. L. Blatner	160	Drl	102	8	..	Pleistocene gravel	43	Force	10	..	Dom	
A 96	10X, 7.2S, 8.1E	Tawasentha Heights Water Company	200	Drl	200	6	..	Pleistocene sand	25	Force	..	42	PWS	Average yield is 2,500 gallons per day.
A 97	10X, 7.2S, 8.1E	Tawasentha Heights Water Company	200	Drl	198	8	..	Pleistocene sand	25	Force	18	42	PWS	Average yield is 5,000 gallons per day.
A 99	10X, 6.6S, 9.1E	Hurstville Water Works	220	Drl	239	6	..	Pleistocene gravel	90	Force	12	..	PWS	Drawdown of 4 feet after pumping 12 gallons per minute for 1 hour.[h]
A 100	10X, 6.6S, 9.1E	Hurstville Water Works	220	Drl	246	6	..	Pleistocene gravel	40	Force	7	..	PWS	Yield at time of drilling in 1929 reported to be 23 gallons per minute.
A 101	10X, 11.4S, 1.8E	H. Smith	770	Drl	115	6	0	Onondaga limestone	60	Force	..	48	Dom	Water is used for a swimming pool.
A 103	10X, 11.7S, 1.7E	H. Smith	750	Drl	180	6	10	Onondaga limestone	85	Force	2	48	Dom	
A 106	10X, 12.3S, 2.3E	R. G. Whelpley	660	Drl	135	6	30	Esopus shale	8	..	30	49	Dom	Water reported to contain hydrogen sulfide.[g]
A 107	10X, 11.5S, 4.0E	Alfred Sieger	450	Drl	96	6	5	Coeymans limestone	20	Force	..	..	Dom	
A 108	10X, 11.1S, 4.5E	F. W. Boughton	520	Dug	26	54	16	Schenectady formation	12	Suction	..	..	Dom	
A 112	10X, 10.3S, 5.9E	A. Bradt	220	Dug	50	6	..	Pleistocene sand	20	Force	..	50	Dom	
A 113	10X, 10.0S, 6.7E	C. Irons	200	Drl	152	6	111	Snake Hill formation	..	..	6	50	Dom	([g])

See footnotes at end of table.

Table 5.—Records of selected wells in Albany County, New York (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
A 114	10X, 9.4S, 7.5E	H. Gochee	230	Dug	14	48	..	Pleistocene sand	5	Suction	..	..	Dom	
A 115	10X, 8.0S, 10.6E	C. W. Smith	60	Drl	345	8	75	Snake Hill formation	..	None	0	..	Dom	Driller reports no yield.
A 116	10X, 8.0S, 10.6E	C. W. Smith	50	Drl	95	8	74	Snake Hill formation	60	Force	4	..	Dom	Rock overlain by 74 feet of blue clay. Water reported to contain hydrogen sulfide.
A 119	10X, 12.9S, 2.4E	W. Van Hoesen	670	Drl	94	6	10	Onondaga limestone	23	Jet	..	..	Dom	
A 120	10X, 13.4S, 2.6E	W. Grosbeck	630	Drl	150	6	1	Onondaga limestone	8	Force	..	..	Dom	
A 121	10X, 13.8S, 3.3E	S. Argiris	560	Drl	129	6	9	Onondaga limestone	20	Force	..	50	Com	([g])
A 122	10X, 13.8S, 4.2E	Harriet Loth	490	Drl	136	6	13	Onondaga limestone	17	..	3	..	Dom	
A 123	10X, 13.8S, 4.2E	Harriet Loth	490	Drl	104	6	0	Onondaga limestone	8	Force	4	..	Dom	
A 124	10X, 13.0S, 3.6E	B. V. Geel, Jr.	500	Dug	15	54	..	Pleistocene till	8	Force	..	..	Dom	
A 125	10X, 12.4S, 4.2E	E. Wisenburn	380	Dug	20	60	20	Pleistocene till	6	Suction	..	..	Dom	
A 128	10X, 12.5S, 5.6E	H. Van Valkenburg	460	Dug	18	48	..	Pleistocene till	6	Suction	..	..	Dom	
A 129	10X, 11.5S, 5.3E	W. C. Hogan Camp	340	Dug	15	48	..	Pleistocene till	3	Suction	..	..	Farm	
A 130	10X, 11.3S, 5.8E	F. Fulmer	340	Drl	314	6	14	Snake Hill formation	..	None	0	..	Dom	Driller reports no yield.
A 131	10X, 11.3S, 5.8E	F. Fulmer	340	Drl	45	6	12	Snake Hill formation	20	Force	..	45	Dom	Water reported to contain hydrogen sulfide.[g]
A 132	10X, 12.0S, 6.2E	R. J. Vadney	250	Drl	32	6	..	Pleistocene gravel	10	..	..	..	Dom	([h])
A 133	10X, 11.7S, 6.9E	J. Van Duren	200	Drl	60	6	48	Snake Hill formation	12	..	..	..	Dom	
A 134	10X, 10.6S, 8.6E	C. Weisel	210	Drl	284	6	..	Pleistocene sand and clay	97	None	..	..	..	Well never used because of quicksand.
A 135	10X, 11.3S, 8.7E	A. DuBuque	225	Drl	70	6	14	Normanskill shale	15	..	..	..	Farm	
A 136	10X, 11.9S, 8.8E	C. A. Bleau	200	Brd	23	24	..	Pleistocene clay and sand	10	Suction	..	..	Dom	
A 137	10X, 10.5S, 9.2E	A. W. Dietz	210	Drl	49	6	..	Pleistocene sand and clay	..	..	10	..	Dom	Well flows. Drawdown reported to be 15 feet when pumping 10 gallons per minute. Water reported to contain hydrogen sulfide.
A 138	10X, 10.4S, 10.0E	M. Schmidt	200	Dug	14	36	..	Pleistocene sand and clay	8	Suction	..	..	Dom	
A 141	10X, 9.9S, 10.8E	Normanskill Farm Dairy	180	Drl	350	8	..	Pleistocene deposits	..	..	..	52	Farm	Water reported to contain hydrogen sulfide.
A 143	10X, 8.7S, 8.5E	Cargill, Inc.	15	Drl	52	10	..	Recent gravel	15	..	350	56	Ind	Finished with 12 feet of 10-inch screen. Packer used at depth of 40 feet. Water reported to contain hydrogen sulfide.[h]
A 144	10X, 8.7S, 8.5E	Cargill, Inc.	15	Drl	58	10	..	Recent gravel and clay	15	..	100	56	Ind	Well finished with 8 feet of 10-inch screen. Packer used at depth of 50 feet.

See footnotes at end of table.

Table 5.—Records of selected wells in Albany County, New York (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
A 145	10X, 8.7S, 8.5E	Cargill, Inc.	15	Drl	60	10	..	Recent alluvium	15	..	75	56	Ind	Well finished with 10 feet of 10-inch screen.
A 147	10X, 9.7S, 11.9E	J. H. Middlebrook	60	Drl	144	6	88	Normanskill shale	85	Jet	6	..	Dom	Water reported to contain hydrogen sulfide.[h]
A 149	10X, 10.3S, 11.7E	Mrs. J. Patterson	200	Drl	253	6	17	Normanskill shale	78	Force	1	..	Dom	
A 152	10X, 10.6S, 10.6E	Calvary Cemetery	200	Drl	240	6	180	Normanskill shale	10	..	..	48	Dom	Water reported to contain hydrogen sulfide.[g]
A 153	10X, 10.8S, 10.4E	D. Murray	210	Dug	21	48	..	Pleistocene sand	3	Force	..	..	Dom	
A 156	10X, 11.3S, 10.6E	R. Williams	200	Drl	219	6	219	Normanskill shale	6	Force	..	..	Farm	Water reported to contain hydrogen sulfide.
A 159	10X, 11.7S, 10.6E	W. H. Heath	170	Drl	242	5	..	Pleistocene clay	15	..	..	..	Ind	Well flowed when drilled. Average yield is 3,500 gallons per day.
A 161	10X, 12.0S, 11.0E	W. L. Heath	180	Drl	60	6	45	Normanskill shale	20	Force	..	..	Farm	
A 162	10X, 11.6S, 11.9E	F. Yaas	50	Drl	189	6	7	Normanskill shale	10	Force	2	..	Dom	Drawdown reported to be 150 feet when pumping at 2 gallons per minute. Water reported to contain hydrogen sulfide.
A 164	10X, 11.4S, 12.0E	Colonial Beacon Oil Co.	50	Drl	301	8	18	Normanskill shale	..	..	5	..	Dom	Well sealed at depth of 42 feet to keep out oil.
A 165	10X, 12.4S, 12.0E	W. Schaffner	60	Drl	97	8	26	Normanskill shale	11	..	6	..	Dom	
A 167	10X, 12.7S, 10.9E	J. Weisheit	180	Drl	137	5	135	Normanskill shale	15	..	..	..	Farm	Water reported to contain hydrogen sulfide.[h]
A 169	10X, 12.4S, 10.0E	W. B. Smith	175	Dug	25	48	..	Pleistocene clay	16	Suction	..	..	Dom	
A 172	10X, 12.9S, 8.8E	W. Mead	200	Dug	25	48	..	Pleistocene clay	1	Force	..	..	Dom	
A 173	10X, 13.1S, 8.3E	A. D. Mead	200	Drl	80	5	..	Pleistocene gravel	5	..	..	..	Farm	Water reported to contain hydrogen sulfide.
A 174	10X, 13.8S, 7.6E	C. F. Brate	175	Drl	273	4½	0	Normanskill shale	25	Force	..	42	PWS	Average yield is 2,500 gallons per day.[g]
A 175	10X, 14.2S, 8.2E	W. T. Hotaling	150	Dug	30	120	..	Pleistocene clay	8	Suction	..	..	Farm	
A 177	10X, 15.3S, 7.1E	H. W. Noble	300	Dug	30	30	..	Pleistocene deposits	43	Force	100	..	Dom	
A 178	10X, 14.8S, 8.8E	Fred Cass	125	Dug	14	48	..	Pleistocene clay	5	Suction	..	..	Farm	
A 181	10X, 14.2S, 9.9E	J. Hotaling	190	Drv	16	1½	..	Pleistocene sand	5	Suction	..	..	Dom	
A 182	10X, 14.7S, 10.1E	E. Grunge	180	Dug	20	36	..	Pleistocene sand	5	Suction	..	..	Dom	
A 183	10X, 15.1S, 10.3E	W. Bennett	175	Drv	10	1½	..	Pleistocene sand	5	Suction	..	49	Dom	([g])
A 186	10X, 15.3S, 10.4E	W. Bennett	175	Dug	22	96	..	Pleistocene sand	5	Suction	25	52	Dom	
A 190	10X, 14.8S, 11.5E	S. W. Belding	140	Drl	105	6	80	Normanskill shale	40	Force	7	..	Dom	([h])
A 191	10X, 16.3S, 9.6E	W. Shear	140	Drl	243	6	243	Pleistocene gravel	90	Force	16	..	Farm	([h])

See footnotes at end of table.

Table 5.—Records of selected wells in Albany County, New York (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
A 193	10X, 10.3S, 11.3E	Our Lady Help of Christians Cemetery	200	Drl	255	8	172	Normanskill shale	24	Force	8	..	Dom	Drawdown reported to be 41 feet when pumped at 8 gallons per minute.h
A 194	10X, 12.9S, 10.1E	D. H. Weisheit	180	Drl	170	5	..	Pleistocene clay	20	Force	..	..	Dom	Water reported to contain hydrogen sulfide.
A 195	10X, 13.3S, 10.6E	G. Hillman & Sons	140	Drl	187	6	183	Normanskill shale	30	Jet	..	..	Farm	Water reported to contain hydrogen sulfide.
A 197	10X, 9.5S, 11.0E	J. H. Magee	180	Drl	223	6	..	Pleistocene gravel	110	Force	9	49	PWS	Average yield is 10,000 gallons per day.
A 198	10X, 9.6S, 3.5E	E. S. Ardizone	490	Drl	400	8	68	Schenectady formation	60	Force	1	53	Farm	
A 199	10X, 4.3S, 8.4E	W. W. Farley	250	Drv	18	2	..	Pleistocene sand	3	Suction	..	45	PWS	Well is one of 20 similar wells used as a source of public water supply for McKownville.
A 200	10X, 16.1S, 2.4E	T. C. Trencherd	750	Drl	182	6	6	Mount Marion formation	9	..	15	..	Dom	Water reported to contain hydrogen sulfide.
A 204	10X, 15.7S, 2.1E	William Axtell	700	Dug	10	36	0	Mount Marion formation	5	Suction	100	..	Dom	
A 205	10X, 2.8S, 0.3E	John Mattson	350	Dug	16	60	..	Pleistocene sand	8	Suction	..	..	Dom	
A 214	10X, 5.7S, 11.5E	Hedrick Brewery Co.	200	Drl	374	10 to 8	214	Snake Hill formation	..	..	1	..	None	Well never used due to low yield.
A 216	10X, 6.5S, 8.1E	New York State Office Building	180	Brd	188	..	172	Snake Hill formation	..	..	..	..	..	Foundation boring 2, project 1533, New York State Department of Architecture.h
A 224	10X, 6.8S, 12.5E	New York Telephone Company	115	Brd	135	..	122	Snake Hill formation	..	..	..	..	..	Foundation boring 2, telephone building, Albany, New York.h
A 229	10Y, 6.3S, 0.2E	Beverwyck Breweries, Inc.	30	Drl	252	10	54	Snake Hill formation	..	..	55	..	None	Well never used, yield not sufficient to meet needs. This and two other wells on property have been destroyed.
A 230	10X, 4.8S, 13.0E	Wolferts Roost Country Club	220	Drl	91	6	64	Snake Hill formation	36	None	½	..	Com	Water from Menands public supply is piped through this well for cooling purposes.
A 231	10X, 7.9S, 12.7E	B. T. Babbitt and Co.	10	Drl	72	8	56	Normanskill shale	15	..	15	..	..	One of two test wells drilled on this property in 1945. No producing well constructed. Some waterbearing sand and gravel encountered between depths of 25 and 56 feet.h
A 240	10Y, 2.5S, 0.6E	William King Estate	280	Drl	171	6	56	Snake Hill formation	20	Force	3	..	Dom	Water reported to contain hydrogen sulfide.
A 241	10Y, 2.5S, 1.5E	Allegheny Ludlum Steel Co.	100	Drl	208	8	30	Snake Hill formation	8	Centrifugal	100	50	Ind	Average yield is 144,000 gallons per day. Drawdown reported to be 22 feet when pumped at 100 gallons per minute.
A 252	10Y, 0.4S, 3.0E	Prediger's Bakery	25	Drl	180	6	39	Snake Hill formation	..	..	20	..	Com	
A 253	10Y, 1.4N, 0.7E	T. E. Maycock	320	Drl	29	8	..	Pleistocene till	22	..	¾	..	Dom	
A 254	10Y, 1.4N, 0.7E	T. E. Maycock	320	Drl	36	8	..	Pleistocene till	28	..	5	..	Dom	
A 256	10Y, 2.6N, 0.5E	P. Breingan	360	Drl	83	6	18	Normanskill shale	16	..	1½	..	Dom	(h)
A 257	10Y, 4.3N, 0.8E	P. J. Welch	240	Drl	215	8	30	Normanskill shale	25	Force	2	..	..	Use of well has been temporarily discontinued.

See footnotes at end of table.

Table 5.—Records of selected wells in Albany County, New York (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
A 259	10Y, 2.0N, 0.3W	Delmer Runkel	350	Drl	40	8	22	Normanskill shale	11	Force	3	..	Dom	Drawdown reported to be 24 feet after pumping 3 gallons per minute for 20 minutes.
A 260	10Y, 2.9N, 0.5W	T. B. Timpane	200	Drl	147	8	8	Normanskill shale	32	Force	2	..	Dom	Drawdown reported to be 113 feet after pumping 2 gallons per minute for 15 minutes.
A 261	10Y, 0.7N, 1.2W	J. A. Wyld	300	Dug	23	36	..	Pleistocene gravel	8	Suction	..	..	Dom	
A 262	10X, 7.4S, 3.2E	H. C. Gott	400	Drl	72	6	5	Schenectady formation	..	Jet	..	40	Dom	Water reported to contain hydrogen sulfide.
A 263	10X, 7.1S, 12.0E	City Ice and Fuel Co.	160	Drl	1,000	8	20	Snake Hill formation	..	..	..	54	None	Well not in use; reported to have been pumped at rate of 15 gallons per minute for 24 hours with a resulting drawdown of 300 feet.[h]
A 265	10X, 0.8S, 10.7E	Latham Water District	300	Drl	244	8	..	Pleistocene gravel	29	Force	640	50	PWS	Drawdown reported to be 10 feet when pumping at 640 gallons per minute. Average yield is 400,000 gallons per day. Well finished with 21 feet of 8-inch screen.[h]
A 266	10X, 1.0S, 10.6E	Latham Water District	300	Drl	303	12	305	Pliestocene gravel	0	..	525	..	PWS	Drawdown reported to be less than 1 foot when pumping at 525 gallons per minute. Average yield is 40,000 gallons per day. Well finished with 40 feet of 12 inch screen. Well plugged at 303 feet.[g]
A 267	10X, 0.1S, 10.7E	Latham Water District	280	Drl	164	8	164	Pleistocene sand	12	Force	645	52	PWS	Drawdown reported to be 30 feet when pumping at 645 gallons per minute. Average yield is 500,000 gallons per day. Well finished with 30 feet of 12-inch screen.[h]
A 268	10X, 0.3S, 10.9E	Latham Water District	285	Drl	48	26	48	Pleistocene gravel	0	Force	118	50	PWS	Drawdown reported to be 33 feet when pumping at 118 gallons per minute. Average yield is 40,000 gallons per day. Well finished with 10 feet of 26-inch screen.[h]
A 269	10X, 0.5S, 5.0E	Latham Water District	340	Drl	70	12	73	Pleistocene sand	14	Force	400	51	PWS	Drawdown reported to be 23 feet when pumping at 400 gallons per minute. Average yield is 200,000 gallons per day. Well finished with 21 feet of 12-inch screen. Well plugged at 70 feet.[h]
A 270	10X, 0.3S, 5.1E	Latham Water District	330	Drl	38	12	38	Pleistocene sand	7	Force	300	50	PWS	Drawdown reported to be 17 feet when pumping at 300 gallons per minute. Average yield is 150,000 gallons per day. Well finished with 10 feet of 12-inch screen.
A 271	10X, 1.6S, 11.1E	Latham Water District	320	Drl	120	12	127	Pleistocene sand	40	Force	660	50	PWS	Drawdown reported to be 9 feet when pumping at 660 gallons per minute. Average yield is 400,000 gallons per day. Well finished with 31 feet of 12-inch screen. Well plugged at 120 feet.[h]

See footnotes at end of table.

Table 5.—Records of selected wells in Albany County, New York (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F)	Use[f]	Remarks
A 272	10X, 3.3S, 9.6E	Latham Water District	290	Drl	228	10	218	Pleistocene sand	24	Force	150	..	PWS	Drawdown reported to be 92 feet when pumping at 150 gallons per minute. Average yield is 65,000 gallons per day. Well finished with 20 feet of 10-inch screen.[h]
A 273	10Y, 1.3N, 3.0W	Latham Water District	210	Drl	161	12	173	Pleistocene gravel	28	Force	705	51	PWS	Drawdown reported to be 29 feet when pumping at 705 gallons per minute. Average yield is 630,000 gallons per day. Well finished with 30 feet of 12-inch screen. Well plugged at 161 feet.[gh]
A 274	10Y, 1.6N, 3.5W	Latham Water District	200	Drl	95	10	94	Pleistocene gravel	..	..	250	51	PWS	
A 288	10X, 10.4S, 5.7E	Josephine Nesbitt	200	Drl	117	6	94	Snake Hill formation	20	Force	7	59	Dom	
A 289	10X, 10.3S, 5.7E	Josephine Nesbitt	200	Drl	140	6	100	Schenectady formation	20	Force	8	..	Farm	
A 311	10Y, 1.3S, 0.6E	J. L. Donhauser	300	Drl	226	6	113	Snake Hill formation	80	Force	..	..	Dom	
A 314	10Y, 3.5S, 0.5E	C. T. Campbell	280	Drl	210	6	58	Snake Hill formation	25	Force	..	52	Farm	Water reported to contain hydrogen sulfide.
A 320	10Y, 3.1N, 1.3E	John Olsway	260	Drl	250	6	80	Normanskill shale	..	..	30	49	Farm	
A 341	10X, 6.8S, 11.6E	U. S. Veteran's Administration	177	Brd	72	..	70	Snake Hill formation	8.5	..	..	..	..	Foundation boring BH-5 Veterans Hospital, Albany, New York.[h]
A 343	10X, 7.1S, 8.5E	Joseph J. Bastian, Jr.	200	Drl	300	6	253	Snake Hill formation	50	Force	..	..	Dom	Rock reported to be overlain by 253 feet of clay.
A 344	10X, 9.8S, 9.8E	George Piazza	160	Dug	26	60	..	Pleistocene sand	3	..	..	52	Dom	Well reported dry occasionally during the summer.
A 347	10X, 13.4N, 1.6W	Cornelius O'Neil	600	Drl	82	6	12	Schenectady formation	..	Centrifugal	..	50	Dom	
A 348	10X, 9.4S, 1.3E	Peter J. Mader	740	Drl	100	8	49	Coeymans limestone	25	Force	3	51	Dom	Drawdown reported to be 55 feet after pumping 3 gallons per minute for 15 minutes.[g]
A 350	10X, 12.3S, 1.4E	R. D. Marshall	760	Drl	115	6	5	Onondaga limestone	50	Force	..	48	Dom	
A 351	10Y, 2.3S, 2.0E	Delaware & Hudson Railroad	50	Dug	60	480	40	Snake Hill formation	6	Centrifugal	..	60	Dom	Average yield is 42,500 gallons per day.
A 352	10X, 6.8S, 12.8E	Flah and Co.	50	Drl	325	12	78	Snake Hill formation	30	..	30	58	None	Well drilled in 1947 for air-conditioning purposes, but did not furnish sufficient quantity. Natural gas reported by driller.[h]
A 356	10X, 10.3S, 10.7E	Bethlehem Central Dist. School No. 6	200	Drl	170	5	..	Pleistocene clay	20	Force	..	..	Dom	Water reported to contain hydrogen sulfide.
A 357	10X, 13.7S, 11.8E	Union Free School No. 1	50	Drl	55	5	25	Normanskill shale	4	..	..	..	Dom	
A 358	10X, 12.1S, 1.7E	L. Grosbeck	760	Drl	67	6	6	Onondaga limestone	..	Force	3	..	Dom	
A 362	10X, 12.6S, 10.1E	L. H. Meyers	180	Drl	370	6	370	Normanskill shale	..	Jet	..	..	Dom	Clay reported from 0 to 248 feet.

See footnotes at end of table.

Table 5.—Records of selected wells in Albany County, New York (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
A 363	10X, 7.7S, 1.6E	Herman Picard	380	Drv	21	1¼	..	Pleistocene sand	4	Suction	50	49	Ind	Drawdown reported very small after pumping 50 gallons per minute for 36 hours. Average yield is 14,400 gallons per day.
A 365	10Y, 6.1S, 0.6E	A. P. W. Paper Co.	20	Dug	25	144	..	Recent clay and gravel	19	Centrifugal	..	..	Ind	
A 367	11X, 2.3S, 9.5E	Palmer Lumber Co.	240	Drl	38	6	9	Normanskill shale	3	None	40	..	Dom	New well; pump is not installed at present time.
A 368	11X, 2.3S, 8.9E	M. Spoor, Sr.	380	Drl	60	6	10	New Scotland limestone	10	..	..	47	Dom	([g])
A 369	11X, 2.2S, 7.7E	Edgar Jarvis	320	Drl	38	6	..	Schoharie grit	..	Suction	30	47	Dom	([g])
A 370	11X, 2.3S, 7.1E	Aquetuck School District No. 2	330	Drl	60	6	..	Onondaga limestone	..	Force	..	50	Dom	
A 371	11X, 2.2S, 6.3E	Sidney Peck	360	Drl	85	6	..	Bakoven shale	18	..	..	49	Dom	Water reported to contain hydrogen sulfide.
A 374	11X, 1.9S, 4.1E	Gordon Haynes	500	Drl	90	6	85	Mount Marion formation	..	None	..	..	Dom	Well flows. Water reported to contain hydrogen sulfide.
A 375	11X, 1.8S, 4.1E	Paul Travis	500	Drl	79	6	..	Mount Marion formation	..	Suction	3	..	Dom	Well flows. Water reported to contain hydrogen sulfide.
A 376	11X, 1.9S, 3.9E	Gertrude Bailey	520	Drl	96	6	60	Mount Marion formation	..	None	..	..	Dom	Well flows. Water reported to contain hydrogen sulfide.
A 377	11X, 2.2S, 3.9E	L. F. Haines	500	Drl	48	6	14	Mount Marion formation	14	..	..	..	Dom	Water reported to contain hydrogen sulfide.
A 378	11X, 3.4S, 2.9E	Percy Sickler	700	Drl	33	6	3	Mount Marion formation	..	Force	6	..	Dom	
A 380	11X, 0.1S, 0.5E	A. Applebee	900	Drl	175	6	2	Mount Marion formation	50	Force	..	50	Dom	([g])
A 382	11W, 2.0S, 12.9E	D. Stanton	1,000	Drl	113	6	45	Ashokan formation	18	None	..	..	Farm	New well; pump is not installed at present time.
A 384	11W, 2.8S, 12.6E	John G. Huemmer	1,040	Dug	40	48	..	Pleistocene till	..	Force	..	..	Farm	
A 385	11W, 3.9S, 12.2E	A. D. Shepard	1,000	Drl	120	6	40	Kiskatom formation	40	Force	..	..	Dom	Average yield is 3,000 gallons per day during the summer. Well supplies a swimming pool.
A 387	11W, 3.7S, 11.7E	C. M. Bogardus	840	Drl	80	6	15	Kiskatom formation	6	..	..	..	Com	
A 388	11W, 3.9S, 10.8E	G. Lockwood	900	Drl	114	6	17	Kiskatom formation	80	Force	..	..	Dom	
A 389	11W, 4.0S, 10.1E	M. S. Palmer	1,050	Drl	125	8	8	Ashokan formation	40	Force	8	..	Farm	
A 390	11W, 4.0S, 9.0E	Grace Richmond	1,100	Dug	20	36	..	Pleistocene till	15	Force	..	..	Dom	
A 391	11W, 4.5S, 7.7E	P. Anderson, Sr.	1,070	Drl	135	6	17	Kiskatom formation	59	Jet	..	..	Farm	
A 392	11W, 4.4S, 6.6E	Peter Fritz	800	Drl	102	6	..	Pleistocene gravel	16	..	..	..	Farm	
A 393	11W, 4.3S, 6.2E	Bertie Mackey	840	Drl	170	6	100	Kiskatom formation	..	None	16	..	Dom	Well flows 16 gallons per minute. Water reported to contain hydrogen sulfide.
A 394	11W, 3.9S, 5.6E	Edith Baitsholts	900	Drl	169	6	1	Kiskatom formation	22	Force	..	..	Farm	
A 395	11W, 3.1S, 5.1E	Loretta C. Roulet	1,040	Drl	135	6	..	Pleistocene till	20	Force	..	..	Dom	Well finished with a screen. Well reported to flow when drilled in 1943.

See footnotes at end of table.

Table 5.—Records of selected wells in Albany County, New York (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
A 396	11W, 2.6S, 4.0E	Manley Mackey	1,250	Drl	120	6	80	Kiskatom formation	15	..	..	47	Dom	[g]
A 398	11W, 3.3S, 3.3E	John C. Nickerson	1,050	Drl	105	6	105	Pleistocene gravel	15	Jet	..	..	Farm	
A 400	11W, 3.9S, 2.0E	Maurice Mercer	1,100	Drl	124	6	80	Kiskatom formation	10	Force	..	43	Farm	Rock reported to be overlain by 80 feet of clay.[g]
A 402	11W, 5.2S, 1.2E	Potter Hollow Creamery	840	Drl	67	6	60	Kiskatom formation	..	None	1	46	Ind	Well flows about 1 gallon per minute. Not used. Water reported to contain hydrogen sulfide.
A 403	11W, 5.5S, 1.1E	John L. Makely	900	Drl	139	6	70	Kiskatom formation	30	Force	..	..	Farm	Rock reported to be overlain by 70 feet of clay.
A 404	11W, 4.7S, 0.5E	Gordon Clapper	1,050	Drl	100	6	7	Kiskatom formation	15	..	..	..	Farm	
A 405	11W, 2.1S, 0.4E	Lester Rivenburg	1,000	Dug	23	36	..	Pleistocene gravel	10	..	..	..	Farm	
A 406	11W, 1.1S, 1.8E	Claude Scutt	1,950	Drl	157	6	14	Kiskatom formation	70	Force	3½	50	Farm	
A 409	11X, 1.5N, 6.4W	L. A. Eldrich	1,600	Drl	174	6	15	Kiskatom formation	27	Force	..	..	Dom	
A 410	11X, 1.8N, 7.2W	L. Gentz	1,400	Drl	113	6	64	Mount Marion formation	29	Force	3	49	Dom	[g]
A 411	11X, 2.1N, 6.8W	George Hale	1,480	Drl	109	6	94	Mount Marion formation	15	Suction	..	..	Dom	
A 412	11X, 2.9N, 7.7W	A. Bolster	1,600	Dug	10	36	..	Pleistocene till	4	Force	..	..	Farm	
A 415	11X, 3.1N, 5.9W	William Illgen	1,560	Drl	75	6	40	Mount Marion formation	15	Jet	..	..	Ind	
A 416	11X, 2.5N, 5.5W	H. L. Erickson	1,540	Dug	13	48	..	Pleistocene till	13	Suction	..	..	Dom	
A 417	11X, 2.6N, 4.0W	Harold Furman	1,400	Dug	20	96	..	Pleistocene till	15	Suction	..	..	Com	
A 418	11X, 1.3N, 3.6W	Ray Gusman	1,300	Drl	52	6	10	Mount Marion formation	20	Force	16	..	Com	
A 419	11X, 3.5N, 2.8W	Otto Messer	1,425	Dug	26	72	..	Pleistocene till	8	..	..	..	Dom	
A 421	11X, 4.4N, 1.5W	William C. Becker	1,460	Drl	79	6	20	Mount Marion formation	30	Jet	10	50	Farm	[g] [h]
A 423	11X, 4.9N, 6.0W	Nina Shufeldt	1,200	Dug	16	96	..	Pleistocene sand	9	Suction	..	..	Dom	[h]
A 425	11X, 5.4N, 6.2W	Howard Skinner	1,040	Drl	38	6	..	Pleistocene gravel	8	..	30	..	Dom	
A 427	11X, 9.0N, 9.2W	I. B. Schoonmaker	960	Drl	160	6	..	Pleistocene gravel	..	None	..	..	Farm	Flows several hundred gallons per day. Clay reported from 0 to 150 feet.
A 428	11X, 8.8N, 7.2W	Jane Brower	1,000	Drl	155	6	0	Onondaga limestone	62	Force	40	..	Dom	
A 429	11X, 8.7N, 6.7W	Emil Horl	1,000	Drl	85	6	72	Onondaga limestone	25	Force	1	50	Farm	Drawdown reported to be 60 feet after pumping 1 gallon per minute for ½ hour.[g]
A 430	11X, 8.8N, 6.2W	Vertie Haverly	1,000	Dug	12	50	..	Pleistocene sand	10	Force	..	..	Dom	
A 432	11X, 8.5N, 5.5W	Joseph Snyder	1,100	Dug	27	36	..	Pleistocene gravel	7	..	..	..	Dom	
A 433	11X, 8.1N, 4.5W	H. Miller	1,200	Dug	18	72	..	Pleistocene deposits	6	Force	..	..	Dom	

See footnotes at end of table.

Table 5.—Records of selected wells in Albany County, New York (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F)	Use[f]	Remarks
A 434	11X, 8.0N, 3.8W	F. Pita	1,200	Drl	110	6	90	Bakoven shale	6	..	..	..	Dom	Rock overlain by 95 feet of clay. (g)
A 435	11X, 7.2N, 2.7W	G. Northrup	1,250	Dug	9	84	..	Pleistocene deposits	6	Suction	..	..	Dom	
A 436	11X, 7.0N, 1.9W	C. J. Garry	1,500	Dug	12	36	..	Pleistocene deposits	4	Suction	..	..	Dom	
A 437	11X, 7.3N, 1.3W	J. Holmberg	1,520	Dug	8	60	4	Mount Marion formation	4	Suction	..	..	Dom	
A 440	11X, 9.6N, 1.4W	Willis S. Gilbert	1,320	Drl	225	4	0	Onondaga limestone	25	Force	..	..	Farm	
A 442	11X, 9.2N, 2.8W	T. M. Holmes	1,400	Drl	67	8	20	Bakoven shale	12	Suction	8	..	Dom	
A 443	11X, 9.3N, 4.5W	Elizabeth Goetz	1,180	Dug	16	60	16	Pleistocene clay	12	Suction	..	..	Dom	Water reported to contain hydrogen sulfide.
A 444	11X, 10.1N, 4.5W	Lynn Hull	1,380	Drl	552	6	132	Bakoven shale	112	Force	2/3	45	Farm	(g)
A 445	11X, 10.8N, 3.0W	Harold Durfee	1,340	Drl	43	6	10	Onondaga limestone	..	None	20	..	Com	Flows 20 gallons per minute. (g)
A 446	11X, 11.1N, 4.0W	H. Herzog	1,400	Drl	209	6	4	Esopus shale	40	Force	..	..	Farm	
A 447	11X, 11.0N, 4.6W	Kenneth Wagner	1,450	Drl	180	6	127	Bakoven shale	90	Force	..	..	Farm	
A 448	11X, 11.6N, 8.7W	Marvin Zimmer	1,080	Drl	76	6	5	Onondaga limestone	5	Suction	8	53	Dom	(g)
A 449	11X, 11.9N, 7.2W	Bernard Settle	1,300	Drl	215	6	3	Helderberg limestone	50	Force	..	..	Farm	Water reported to contain hydrogen sulfide.
A 450	11X, 11.9N, 6.1W	D. W. Stevens	1,100	Drl	122	6	6	Helderberg limestone	80	Jet	..	50	Dom	
A 451	11X, 12.4N, 4.1W	Newton Clickman	1,300	Dug	12	36	..	Pleistocene deposits	3	Pitcher	..	..	Dom	
A 452	11X, 13.0N, 3.7W	C. W. Paul	1,200	Drl	75	6	65	Schenectady formation	65	Force	..	..	Dom	
A 453	11X, 13.3N, 3.1W	M. J. Clickman	1,100	Drl	66	6	12	Schenectady formation	8	Jet	..	..	Farm	
A 454	11X, 11.3N, 0.1W	L. D. Bates	400	Drl	303	4	98	Schenectady formation	..	None	..	..	Dom	Flows a few gallons per day. Well can be pumped dry with a pitcher pump and takes several days to recover. Clay reported 0 to 98 feet.
A 455	11X, 11.5N, 0.2W	Arthur M. Platz	400	Drl	16	6	..	Pleistocene gravel	..	Suction	..	..	Dom	Flows several gallons per hour.
A 456	11X, 14.8N, 2.3W	Philip Leambardt	450	Dug	12	36	13	Schenectady formation	7	Suction	..	..	Farm	
A 457	11X, 16.6N, 0.6W	S. P. Price	460	Drl	100	6	25	Schenectady formation	12	..	..	..	Farm	Water reported to contain hydrogen sulfide.
A 459	11X, 17.2N, 1.6W	W. C. Lockyer	450	Drl	125	8	61	Schenectady formation	100	Force	½	..	Farm	Water reported to contain hydrogen sulfide.
A 460	11X, 14.9N, 3.7W	A. Pullman	700	Dug	16	36	..	Pleistocene till	10	Suction	..	..	Dom	Water reported to contain hydrogen sulfide.
A 461	11X, 14.0N, 3.9W	Earl J. Sturgess	950	Dug	12	96	4	Schenectady formation	4	Suction	..	..	Dom	
A 462	11X, 14.0N, 5.5W	Daniel Clykeman	1,040	Dug	20	48	..	Pleistocene till	10	Force	..	..	Farm	
A 463	11X, 14.0N, 6.1W	F. C. Sand	1,200	Drl	75	6	68	Schenectady formation	..	Suction	5	..	Dom	Flows 2½ gallons per minute.

See footnotes at end of table.

Table 5.—Records of selected wells in Albany County, New York (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
A 464	11X, 14.0N, 6.6W	Sophia Lewis	1,240	Dug	30	48	..	Pleistocene clay	10	..	..	50	Dom	
A 465	11X, 15.8N, 5.5W	Williamson Brothers	800	Dug	17	24	..	Pleistocene till	12	Suction	..	..	Dom	
A 468	11X. 15.9N, 6.6W	Lewis Barber	1,100	Dug	15	36	15	Pleistocene till	7	Pitcher	..	..	Dom	
A 470	11X, 15.2N, 7.5W	Fred Stebbins	1,200	Drl	60	6	6	Schenectady formation	30	Force	..	..	Dom	
A 472	11X, 15.9N, 8.8W	Margaret M. Gage	1,120	Drl	300	6	6	Schenectady formation	..	..	2½	40	Farm	Water reported to contain hydrogen sulfide.[g]
A 474	11W, 4.5S, 6.1E	Dean Davis	800	Drl	137	6	..	Pleistocene gravel	..	Suction	..	48	Dom	Supplies seven houses.
A 475	11W, 4.3S, 6.0E	Alleva Dairy	820	Drl	98	6	2	Kiskatom formation	..	Jet	20	..	Ind	Well reported to flow when drilled in 1945. Flow ceased when another well was drilled nearby.
A 476	11W, 4.2S, 6.0E	Benjamin Snyder	900	Drl	126	6	6	Kiskatom formation	30	Jet	8	..	Farm	
A 477	11W, 3.2S, 1.2E	George Turner	920	Drl	262	4	..	Pleistocene sand	35	Force	5	..	Farm	
A 478	11X, 6.1N, 6.6W	Merlyn Arnold	1,075	Drl	110	6	110	Pleistocene sand	2	Jet	8	..	Farm	
A 482	11X, 6.8N, 8.8W	I. V. Shultes	1,600	Dug	24	48	..	Pleistocene till	..	Suction	3	..	Dom	Another similar well is near same location.
A 483	11X, 7.8N, 7.9W	A. Wiltsie	910	Dug	11	48	..	Pleistocene till	5	..	3	..	Dom	
A 484	11X, 6.5N, 9.4W	Harry Shultes	1,800	Dug	12	48	12	Pleistocene till	..	..	..	..	Farm	
A 485	11X, 3.8N, 7.0W	E. Bemsen	1,880	Drl	60	6	40	Hamilton group	40	Force	3	..	Farm	Driller reports clay and hardpan overlie bedrock.
A 486	11X, 2.9N, 9.3W	William Wood	1,920	Drl	80	6	40	Hamilton group	25	Force	5	47	Farm	
A 487	11X, 2.2N, 9.1W	Helen Scheffel	1,900	Drl	110	6	60	Hamilton group	25	Force	..	..	Dom	Driller reports till overlies bedrock.
A 488	11X, 2.3N, 10.7W	Arthur Lowe	2,040	Drl	165	6	5	Hamilton group	50	Force	8	..	Dom	
A 489	11X, 2.7N, 12.0W	Walter J. Luby	1,990	Drl	149	6	5	Hamilton group	60	Jet	6	..	Farm	
A 490	11X, 8.4N, 8.0W	E. B. Schoonmaker	960	Dug	11	36	..	Pleistocene till	5	..	..	..	Dom	
A 491	11X, 4.3N, 2.2W	Clayton Barber	1,600	Dug	22	48	..	Pleistocene till	..	..	..	..	Dom	
A 492	11X, 4.7N, 2.5W	David Knowles	1,480	Drl	100	6	80	Hamilton group	..	Pitcher	3	48	Dom	
A 493	11X, 2.3N, 2.1W	Peter Hotaling	1,310	Drl	104	6	45	Hamilton group	10	..	20	..	Farm	
A 494	11W, 0.9S, 5.9E	Robert Lundberg	1,340	Drl	102	6	..	Pleistocene gravel	36	Force	2	..	Farm	
A 495	11W, 1.9S, 7.0E	Walter Joy	1,250	Drl	217	6	164	Hamilton group	134	Force	6	..	Farm	Reported drawdown 58 feet after several hours pumping at about 6 gallons per minute.
A 496	11W, 2.4S, 7.8E	Vincent Bilicka	1,140	Drl	152	6	..	Pleistocene gravel	18	Jet	10	..	Dom	Owner reports water contains about 6 parts per million of iron.
A 497	11W, 1.5S, 8.8E	William Furman	1,320	Drl	180	6	170	Kiskatom formation	..	Force	5	..	Dom	Driller reports till overlies bedrock.

See footnotes at end of table.

Table 5.—Records of selected wells in Albany County, New York (Concluded)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
A 498	11X, 0.3N, 3.6W	Jesse Britton	1,300	Drl	27	6	..	Pleistocene gravel	..	Pitcher	20	..	Dom	
A 499	10X, 17.1S, 0.9E	August Fassler	800	Drl	50	6	..	Hamilton group	..	Pitcher	3	..	Dom	
A 500	10X, 17.4S, 0.9E	Charles Fassler	760	Drl	140	6	70	Hamilton group	..	Force	..	..	Dom	
A 501	10X, 15.2S, 5.1E	S. Gallup	420	Drl	120	6	..	Onondaga limestone	..	Jet	..	..	Dom	Inadequate yield reported during period of drought.
A 502	10X, 14.4S, 5.3E	Anson Thiedmann	360	Dug	18	48	..	Pleistocene till	4	Pitcher	3	..	Dom	
A 503	10X, 15.1S, 3.8E	Jacob Taylor	830	Dug	25	48	..	Pleistocene till	..	Pitcher	3	..	Dom	
A 504	11X, 2.3N, 10.7W	Ruth Packard	2,040	Drl	125	6	..	Pleistocene sand	40	Force	15	..	Dom	

a. For explanation of location symbols see section, "Methods of investigation."
b. Approximate altitude from topographic map.
c. Brd, bored; Drl, drilled; Drv, driven.
d. Reported average water level.
e. For explanation of methods of lift and pumping equipment see section, "Ground water, recovery."
f. Com, commercial; Dom, domestic; Ind, industrial; PWS, public water supply.
g. For chemical analyses see table 3.
h. For driller's log see table 4.